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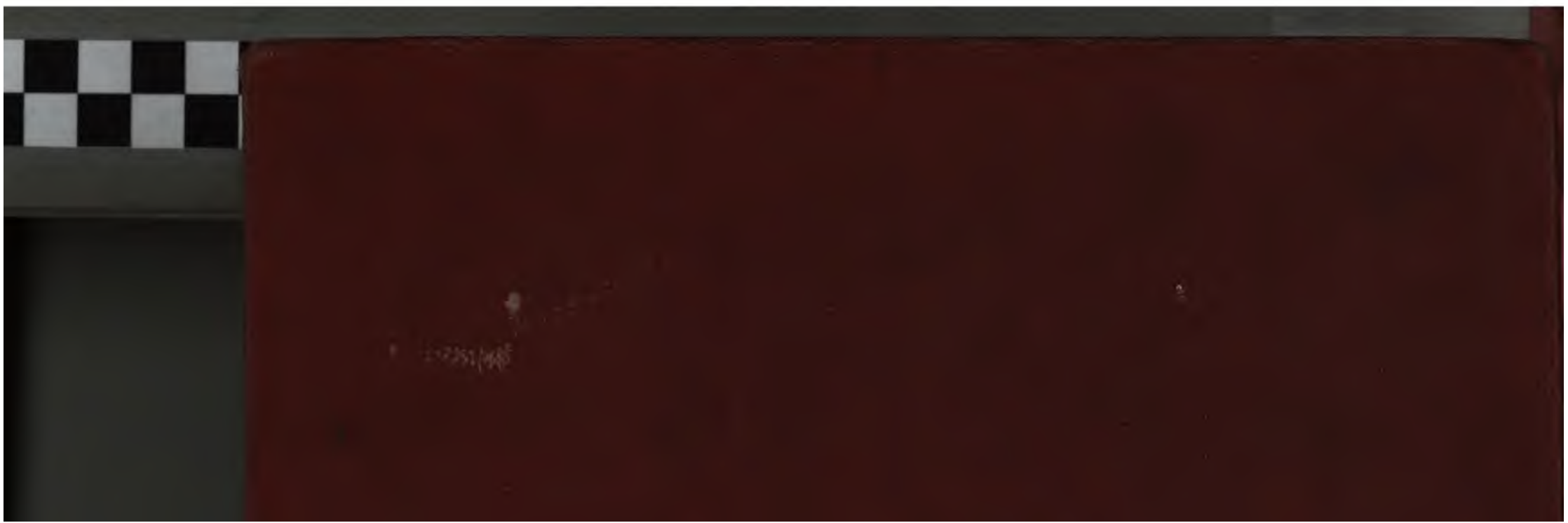

THE MINERAL INDUSTRY

ITS

STATISTICS, TECHNOLOGY AND TRADE

DURING

1914

FOUNDED BY RICHARD P. ROTHWELL

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THE STATE GEOLOGICAL SURVEYS

Of the 46 States of the Union, 35 have organised geological surveys, these comprising nearly all of the States in which the mining industry is important. The organization of a geological survey in Massachusetts is under consideration. Certain States which have no geological survey have officials who give attention to the mining industry. Thus, California has a State mineralogist, while Idaho has a State mine inspector who collects statistics of mineral production. The States having organised geological surveys, together with the names and addresses of the respective State geologists, as of Jan. 1, 1915, are given in the following list:

STATE GEOLOGISTS.

State.	Name and Address.	State.	Name and Address.
Alabama	Eugene A. Smith, University.	New York	John M. Clarke, Albany.
Arkansas	N. F. Drake, Fayetteville.	N. Carolina	Joseph Hyde Pratt, Chapel Hill.
Connecticut	Wm. N. Rice, Hartford.	N. Dakota	A. G. Leonard, Grand Forks.
Colorado	R. D. George, Director, Boulder.	Ohio	J. A. Bownocker, Columbus.
Florida	E. H. Sellards, Tallahassee.	Oklahoma	C. W. Shannon, Norman.
Georgia	S. W. McCallie, Atlanta.	Pennsylvania	Richard R. Hice, Beaver.
Illinois	F. W. DeWolf, Director, Urbana	Rhode Island	Chas. W. Brown, Providence.
Indiana	Edward Barrett, Indianapolis.	S. Carolina	Earle C. Sloan, Charleston.
Iowa	Geo.F.Kay, Director, Des Moines	S. Dakota	E. C. Perisho, Vermillion.
Kansas	Erasmus Haworth, Lawrence.	Tennessee	A. H. Purdue, Nashville.
Kentucky	J. B. Hoenig, Frankfort.	Texas	W. B. Phillips, Austin.
Maryland	William Bullock Clark, Baltimore.	Vermont	G. H. Perkins, Burlington.
Michigan	R. C. Allen, Lansing.	Virginia	Thos. L. Watson, Charlottesville.
Mississippi	E. N. Lowe, Jackson.	Washington	Henry Landes, Seattle.
Missouri	H. A. Buehler, Rolla.	West Virginia	I. C. White, Morgantown.
Nebraska	E. H. Barbour, Lincoln.	Wisconsin	W. O. Hotchkiss, Madison.
New Jersey	H. B. Kümmel, Trenton.	Wyoming	L. W. Trumbull, Cheyenne.
New Mexico	Chas. T. Kirk, Albuquerque.		

STATE MINE INSPECTORS, COMMISSIONERS, ETC.

State.	Name and Address.
Alabama	C. H. Nesbit, Chief Mine Inspector, Birmingham.
Alaska	S. S. Smith, Mine Inspector, Juneau.
Arizona	G. H. Bolin, State Mine Inspector, Phoenix.
Arkansas	G. B. Tucker, Commissioner, Bureau of Mines, Manufactures and Agriculture, Little Rock. John T. Fuller, State Mineralogist. Tom Shaw, State Mine Inspector, Midland.
California	F. McN. Hamilton, State Mineralogist, San Francisco.
Colorado	T. R. Henahen, Commissioner, Denver. James Dalrymple, Coal Mine Inspector, Denver.
Idaho	R. N. Bell, State Mine Inspector, Boise.
Indiana	E. A. Perkins, Chief Mine Inspector, Indianapolis.
Iowa	E. M. Gray, Pres. State Mining Board, Des Moines.
Kansas	Francis Keegan, State Mine Inspector.
Kentucky	C. J. Norwood, Chief Mine Inspector, Lexington.
Maryland	Wm. Walters, State Mine Inspector, Midland.
Michigan	R. M. Andrews, Commissioner of Mineral Statistics, Lansing.
Minnesota	F. A. Wildes, State Mine Inspector, Hibbing.
Missouri	George Bartholomaeus, Secretary, Bureau of Mines and Mines Inspection, Jefferson City. Geo. Hill, Chief Mine Inspector, Bevier.
Montana	W. B. Orem, State Mine Inspector. John Sanderson, State Coal Mine Inspector, Red Lodge.
Nevada	Ed. Ryan, Carson City.
New Mexico	Rees H. Beddow, Mine Inspector Gallup, N. M.
New York	W. W. Jones, State Mine Inspector, Albany.
North Dakota	Jas. W. Bliss, State Engineer, Bismark.
Ohio	J. C. Davies, Chief Inspector of Mines, Columbus.
Oklahoma	Ed. Boyle, Chief Inspector, McAlester.
Oregon	H. M. Parks, Director, Bureau of Mines, Corvallis.
Pennsylvania	James Roderick, Chief Department of Mines, Harrisburg.
South Dakota	O. E. Ellerman, State Mine Inspector, Lead.
Tennessee	Geo. E. Sylvester, Chief Mine Inspector, Rockwood.
Texas	I. J. Broman, State Mine Inspector, Round Rock.
Utah	J. E. Pettit, State Mine Inspector, Salt Lake City.
Virginia	R. B. Roanoe, Mine Inspector, Richmond.
Washington	Jas. Bagley, State Inspector of Coal Mines, Seattle.
West Virginia	Earl Henry, Chief, Department of Mines, Charleston.

VALUE OF FOREIGN COINS

ESTIMATE BY DIRECTOR OF THE MINT, JAN. 1, 1915.

Country.	Standard.	Monetary Unit.	Value in Terms of U.S. Gold Dollar.	Coins.
Argentine Republic.	Gold...	Peso	$0.965	Gold: argentine ($4.824) and ½ argentine. Silver: peso and divisions. Currency: Depreciated paper, convertible at 44 per cent. of face value.
Austria-Hungary..	Gold...	Crown	.203	Gold: 10 and 20 crowns. Silver, 1 and 5 crowns. Member of Latin Union; gold is the actual standard.
Belgium	Gold...	Franc	.193	Gold: 10 and 20 francs. Silver: 5 francs.
Bolivia	Gold...	Boliviano	.389	Silver: boliviano and divisions, 12½ bolivianos equal 1 pound sterling.
Brasil	Gold...	Milreis	.546	Gold: 5, 10 and 20 milreis. Silver: ½, 1 and 2 milreis. Currency: Government paper. Exchange rate about 25 cts. to the milreis.
British Colonies in America.	Gold...	Dollar	1.000	.....
in Australasia and Africa.	Gold...	Pound sterling	4.8665	.....
Central America. Costa Rica.	Gold...	Colon	.465	Gold: 2, 5, 10 and 20 colons ($9.307) Silver: 5, 10, 25 and 50 centimos.
British Honduras.	Gold...	Dollar	1.000	.....
Nicaragua	Gold ..	Cordova	1.000	.....
Guatemala... Honduras.... Salvador.....	Silver .	Peso	.365	Silver: peso and divisions. Guatemala: Currency, inconvertible paper, exchange rate 16 to 18 pesos = $1.00. Honduras: Currency, bank notes. Salvador: Currency, convertible into silver on demand.
Chile	Gold...	Peso	.365	Gold: escudo ($1.825), doubloon ($3.650), and condor ($7.300). Silver: peso and divisions. Currency: Inconvertible paper; exchange rate, approximately, $0.14.
China	Silver	Tael.. Amoy	.599	.....
		Canton	.597	.....
		Cheefoo	.570	.....
		Chin Kiang	.585	.....
		Fuchau	.554	.....
		Haikwan (customs)	.610	.....
		Hankow	.560	.....
		Kisochow	.580	.....
		Nankin	.593	.....
		Niuchwang	.562	.....
		Ningpo	.576	.....
		Peking	.584	.....
		Shanghai	.547	.....
		Swatow	.553	.....
		Takau	.603	.....
		Tientsin	.580	.....
		Dollar Yuan	.436	.....
		Dollar Hongkong	.394	.....
		Dollar British	.394	.....
		Dollar Mexican	.397	.....
Colombia	Gold...	Dollar	1.000	Gold: condor ($9.647) and double condor. Silver: peso. Currency: Inconvertible paper; exchange rate, approximately, $102 paper to $1 gold.
Denmark	Gold...	Crown	.268	Gold: 10 and 20 crowns.
Ecuador	Gold...	Sucre	.487	Gold: 10 sucres ($4.8665). Silver: sucre and divisions.

NOTE.—The coins of silver-standard countries are valued by their pure silver contents, at the average market price of silver for the three months preceding January 1, 1915.

Country.	Standard.	Monetary Unit.	Value in Terms of U.S. Gold Dollar.	Coins.
Egypt	Gold	Pound (100 piasters)	4.943	Gold: pound (100 piasters), 5, 10, 20 and 50 piasters. Silver: 1, 2, 5, 10 and 20 piasters. The actual standard is the British pound sterling, which is legal tender for 97⅛ piasters.
Finland	Gold	Mark	.193	Gold: 20 marks ($3.859), 10 marks ($1.93).
France	Gold	Franc	.193	Gold: 5, 10, 20, 50 and 100 francs. Silver 5 francs. Member of Latin Union; gold is the actual standard.
German Empire	Gold	Mark	.238	Gold: 5, 10 and 20 marks.
Great Britain	Gold	Pound sterling	4.8665	Gold: sovereign (pound sterling) and ½ sovereign.
Greece	Gold	Drachma	.193	Gold: 5, 10, 20, 50 and 100 drachmas. Silver: 5 drachmas. Member of Latin Union; gold is the actual standard.
Haiti	Gold	Gourde	.965	Gold: 1, 2, 5 and 10 gourdes. Silver: gourde and divisions. Currency: Inconvertible paper; exchange rate, approximately, $0.2941.
India (British)	Gold	Pound sterling*	4.8665	Gold: sovereign (pound sterling). Silver: rupee and divisions.
Italy	Gold	Lira	.193	Gold: 5, 10, 20, 50 and 100 lire. Silver: 5 lire. Member of Latin Union; gold is the actual standard.
Japan	Gold	Yen	.498	Gold: 5, 10 and 20 yen. Silver: 10, 20 and 50 sen.
Liberia	Gold	Dollar	1.000	Currency: Depreciated silver token coins. Customs duties are collected in gold.
Mexico	Gold	Peso†	) 8	Gold: 5 and 10 pesos. Silver: dollar‡ (or peso) and divisions. Mexican exchange rate fluctuating and uncertain.
Netherlands	Gold	Florin	.402	Gold: 10 florins. Silver: 2½, 1 florin, and divisions.
Newfoundland	Gold	Dollar	1.014	Gold: 2 dollars ($2.027).
Norway	Gold	Crown	.268	Gold: 10 and 20 crowns.
Panama	Gold	Balboa	1.000	Gold: 1, 2½, 5, 10 and 20 balboas. Silver: peso and divisions.
Paraguay	Silver	Peso	.365	Currency: Depreciated paper, exchange rate 1550 per cent.
Persia	Silver	Kran‡‡	.0875	Gold: ½, 1, and 2 tomans ($3.409). Silver: ¼, ½, 1, 2 and 5 krans.
Peru	Gold	Libra	4.8665	Gold: ½ and 1 libra. Silver: sol and divisions.
Philippine Islands	Gold	Peso	.500	Silver peso: 10, 20 and 50 centavos.
Portugal	Gold	Milreis	1.080	Gold: 1, 2, 5 and 10 milreis.
Roumania	Gold	Leu	.193	Currency: Inconvertible paper; exchange rate, approximately, $0.9394.
Russia	Gold	Ruble	.515	Gold: 5, 7½, 10 and 15 rubles. Silver: 5, 10, 15, 20, 25, 50 and 100 copecks.
Santo Domingo	Gold	Dollar	1.000	.....
Servia	Gold	Dinar	.193	.....
Siam	Gold	Tical	.371	.....
Spain	Gold	Peseta	.193	Gold: 25 pesetas. Silver: 5 pesetas. Valuation is for the gold peseta; currency is silver circulating above its metallic value, approximately, $0.1794.
Straits Settlement	Gold	Pound sterling§	4.8665	Gold: sovereign (pound sterling). Silver: dollar and divisions.
Sweden	Gold	Crown	.268	Gold: 10 and 20 crowns.
Switzerland	Gold	Franc	.193	Gold: 5, 10, 20, 50 and 100 francs. Silver: 5 francs. Member of Latin Union; gold is the actual standard.
Turkey	Gold	Piaster	.044	Gold: 25, 50, 100, 250 and 500 piasters. 100 piasters equal to the Turkish £.
Uruguay	Gold	Peso	1.034	Gold: peso. Silver: peso and divisions.
Venezuela	Gold	Bolivar	.193	Gold: 5, 10, 20, 50 and 100 bolivars. 5 bolivars.

* The sovereign is the standard coin of India, but the rupee ($0.32441/2) is the current coin, valued at 15 to the sovereign.
† Seventy-five centigrams fine gold.
‡ Value in Mexico, $0.498.
‡‡ The Gold Kran $0.1704.
§ The current coin of the Straits Settlements is the silver dollar issued on Government account, and which has been given a tentative value of $0.567.

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Country.	Standard.	Monetary Unit.	Value in Terms of U.S. Gold Dollar.	Coins.
Egypt	Gold...	Pound (100 piasters)..	4.943	Gold: pound (100 piasters), 5, 10, 20 and 50 piasters. Silver: 1, 2, 5, 10 and 20 piasters. The actual standard is the British pound sterling, which is legal tender for 97⅛ piasters.
Finland	Gold...	Mark	.193	Gold: 20 marks ($3.859), 10 marks ($1.93).
France	Gold...	Franc	.193	Gold: 5, 10, 20, 50 and 100 francs. Silver 5 francs. Member of Latin Union; gold is the actual standard.
German Empire	Gold...	Mark	.238	Gold: 5, 10 and 20 marks.
Great Britain	Gold...	Pound sterling	4.8665	Gold: sovereign (pound sterling) and ½ sovereign.
Greece	Gold...	Drachma	.193	Gold: 5, 10, 20, 50 and 100 drachmas. Silver: 5 drachmas. Member of Latin Union; gold is the actual standard.
Haiti	Gold...	Gourde	.965	Gold: 1, 2, 5 and 10 gourdes. Silver: gourde and divisions. Currency: Inconvertible paper; exchange rate, approximately, $0.2941.
India (British)	Gold...	Pound sterling*	4.8665	Gold: sovereign (pound sterling). Silver: rupee and divisions.
Italy	Gold...	Lira	.193	Gold: 5, 10, 20, 50 and 100 lire. Silver: 5 lire. Member of Latin Union; gold is the actual standard.
Japan	Gold...	Yen	.498	Gold: 5, 10 and 20 yen. Silver: 10, 20 and 50 sen.
Liberia	Gold...	Dollar	1.000	Currency: Depreciated silver token coins. Customs duties are collected in gold.
Mexico	Gold...	Peso†	9 8	Gold: 5 and 10 pesos. Silver: dollar‡ (or peso) and divisions. Mexican exchange rate fluctuating and uncertain.
Netherlands	Gold...	Florin	.402	Gold: 10 florins. Silver: 2½, 1 florin, and divisions.
Newfoundland	Gold...	Dollar	1.014	Gold: 2 dollars ($2.027).
Norway	Gold...	Crown	.268	Gold: 10 and 20 crowns.
Panama	Gold...	Balboa	1.000	Gold: 1, 2½, 5, 10 and 20 balboas. Silver: peso and divisions.
Paraguay	Silver .	Peso	.365	Currency: Depreciated paper, exchange rate 1550 per cent.
Persia	Silver.	Kran‡‡	.0875	Gold: ½, 1, and 2 tomans ($3.409). Silver: ¼, ½, 1, 2 and 5 krans.
Peru	Gold...	Libra	4.8665	Gold: ½ and 1 libra. Silver: sol and divisions.
Philippine Islands	Gold...	Peso	.500	Silver peso: 10, 20 and 50 centavos.
Portugal	Gold...	Milreis	1.080	Gold: 1, 2, 5 and 10 milreis.
Roumania	Gold...	Leu	.193	Currency: Inconvertible paper; exchange rate, approximately, $0.9394.
Russia	Gold...	Ruble	.515	Gold: 5, 7½, 10 and 15 rubles. Silver: 5, 10, 15, 20, 25, 50 and 100 copecks.
Santo Domingo	Gold...	Dollar	1.000	.....
Servia	Gold...	Dinar	.193	.....
Siam	Gold...	Tical	.371	.....
Spain	Gold...	Peseta	.193	Gold: 25 pesetas. Silver: 5 pesetas. Valuation is for the gold peseta; currency is silver circulating above its metallic value, approximately, $0.1794.
Straits Settlement.	Gold...	Pound sterling§	4.8665	Gold: sovereign (pound sterling). Silver: dollar and divisions.
Sweden	Gold...	Crown	.268	Gold: 10 and 20 crowns.
Switzerland	Gold...	Franc	.193	Gold: 5, 10, 20, 50 and 100 francs. Silver: 5 francs. Member of Latin Union; gold is the actual standard.
Turkey	Gold...	Piaster	.044	Gold: 25, 50, 100, 250 and 500 piasters. 100 piasters equal to the Turkish £.
Uruguay	Gold...	Peso	1.034	Gold: peso. Silver: peso and divisions.
Venesuela	Gold...	Bolivar	.193	Gold: 5, 10, 20, 50 and 100 bolivars. 5 bolivars.

* The sovereign is the standard coin of India, but the rupee ($0.3244⅜) is the current coin, valued at 15 to the sovereign.

† Seventy-five centigrams fine gold.

‡ Value in Mexico, $0.498.

‡‡ The Gold Kran $0.1704.

§ The current coin of the Straits Settlements is the silver dollar issued on Government account, and which has been given a tentative value of $0.567.

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INTRODUCTION

The object of MINERAL INDUSTRY is to bring together as complete a record as possible of the year's progress in the mining and metallurgical industries. It is *not* intended simply as a compilation of production statistics; although such data are necessarily a part of a record of this kind, they are here used primarily as an indication of progress. Those seeking only production statistics will find a fuller record in the official statistical publications of the various governments, from which much of the statistical information here given is obtained. Our desire is to combine the leading statistics with such extracts from the current literature as have an important bearing on the subject in hand, coupled with sufficient discussion of the prevailing commercial conditions to show the trend of the financial side of the industry, so as to make a well-rounded review of the progress of the year in each of the various mineral and metallurgical industries. Naturally, such a review is limited in size and the space can not be devoted to the various subjects that is sometimes desired. The information, however, is usually sufficiently detailed to serve the purpose of the average reader, and while not complete enough to meet in full the demands of the specialist or investigator, will furnish him with the more important data as a foundation on which to build a more complete investigation of the subject.

The scope of the volume is International in character. So far as it is possible, the information given includes the various countries of the world producing important quantities of a given material. However, it must be borne in mind that it is an American-made book, and if it appears to foreign readers that sufficient space has not been devoted to foreign fields, it is not a result of any desire on the part of the author or editor to minimize the importance of the foreign production, or to magnify the importance of the American production; it is simply a consequence of the relative availability of reliable, up-to-date information from the various fields, those nearest home naturally having the advantage.

In order to make the reports as representative and authoritative as possible, their preparation has been turned over to specialists, the reader, in this way, getting the benefit not only of the items of information included in the report, but also of that expert's judgment concerning the relative importance of the information. The results obtained in this way

are much more reliable and satisfactory than could be obtained in a scissors-and-paste compilation by the Editor, who could not possibly be acquainted with conditions in more than a few fields.

A rather marked departure has been made this year in the make-up of the List of Contributors. In previous years it has been customary to class as a contributor the author of any material that was quoted *in extenso* from another source, even though none of the work was done primarily for MINERAL INDUSTRY. Eventually the actual contributors were outnumbered by the apparent contributors, with the result that often men who had exerted no effort in behalf of MINERAL INDUSTRY received equal recognition with those who had expended considerable time and energy in the preparation of special material. In justice to those who have labored for the success of MINERAL INDUSTRY, and thus for the profession as a whole, we include this year in our List of Contributors only those who have actually prepared the material under their names for use in this volume. For all other material included, due credit is given to the original source in the text or the footnotes.

A number of the mineral industries, particularly those connected with the pottery and building trades, are so widely scattered that their treatment is beyond the scope of a general report of this kind. A few industries relating to manufactured substances are included, where the production of the manufactured material is closely associated with that of the raw material, or where it is replacing to a considerable extent some natural material, *e.g.*, coke and cement.

The statistics presented are the best available at the time of publication. Wherever possible they are the official figures of the country in question. Where it is known, the source of the statistics is shown. When conditions are at their best, there is great difficulty in getting even approximately complete statistics within a few months after the close of the year. This year the European war has made the collection of statistics much more difficult and, in many cases, entirely impossible. For this reason the statistical side of the present volume will not be found quite so complete as the preceding ones. This also applies in some cases to general information as well, for almost nothing at all could be learned concerning some producing localities.

For many of the production statistics we are indebted to the U. S. Geological Survey, and to the corresponding departments of the various foreign countries; for the United States imports and exports, to E. E. Pratt, Chief of the Bureau of Foreign and Domestic Commerce. Acknowledgment is also due to many of the State Geological Surveys and mining bureaus for statistical and general information.

In most cases, the sources of information are shown either in the text or in footnotes; any variation from this rule is an unintentional oversight.

Our indebtedness to the columns of the technical press is gratefully acknowledged, particularly to *Engineering and Mining Journal, Mining and Scientific Press, Metallurgical and Chemical Engineering, Mining and Engineering World, Coal Age, Salt Lake Mining Review, Mining Journal, Mining Magazine, Canadian Mining Journal, Australian Mining Standard, South African Mining Journal, L'Echo des Mines et de la Metallurgie* and *Glückauf.*

Special acknowledgment is due for special coöperation from T. T. Read of the editorial staff of *Mining and Scientific Press*, H. C. Parmelee, of *Metallurgical and Chemical Engineering*, and A. T. Shurick, of *Coal Age*, and to the Director of the U. S. Geological Survey.

The make-up of the volume is similar to that of the preceding volumes, the various industries being taken up in alphabetical order, except in cases where similar materials are classed under a general heading, *e.g.*, Abrasives. In the latter part of the volume will be found articles of general interest. The statistical tables at the end are made up from the official reports of the various countries. As these are often a year or more behind, the tables are completed to date, so far as possible, with unofficial figures. This will undoubtedly increase the value of the tables, even though some of the figures given are only approximately correct. All unofficial figures in the tables are given in **full-faced type** to distinguish them from the official figures. The index has been made as detailed as possible, considering the space that can be devoted to it, and all items are thoroughly cross-indexed.

As indicated on the title page, this volume is a supplement to Volumes I–XXII, but at the same time it is more than a supplement. It not only adds the data for the year 1914, but also gives corrections of the figures incorporated in previous volumes. Hence, it is important in using MINERAL INDUSTRY always to use the latest volume even for figures for previous years, in order to get the benefit of these corrections, except, of course, in the case of the less important statistics, which are not carried from year to year, but are given only once.

In conclusion, the Editor expresses his gratitude and indebtedness to the Contributors of the various articles incorporated in this volume for their hearty coöperation, for to them is due a large measure of the credit for whatever of value the volume may contain.

G. A ROUSH.

SOUTH BETHLEHEM, PA.
July 1, 1915.

READJUSTMENTS IN THE MINERAL INDUSTRIES

By George Otis Smith

Director, U. S. Geological Survey

Never before has the census of the world's mineral industries possessed greater interest and value. Disturbance of international trade has brought in its train changes in market relations, with the result that industrial conditions in every country have been affected. Many a manufacturer who thought little of the source of his raw material, and many a mine operator who regarded his market as assured, have been rudely awakened to the fact that the countries of this small world are interdependent. The enforced shutdown of Belgian smelters may have opened new markets to American spelter, but the blockade of German ports closed a large market for American copper; the embargo on British coal creates new demands for the product of American mines, but the closing of North Sea ports to commerce shuts off from American farms the needed supplies of German potash. So, in manifold ways, the currents of international commerce have been changed. It is too early to forecast the exact lines which world trade will finally follow, but we may try to ascertain the fundamental facts that will condition if not control that readjustment, in so far as the mineral industries are concerned.

The development of transportation has not only made the problem of intra-national commerce and of domestic markets a complex one, but in this century, with uninterrupted commerce, the resources of the whole world must be considered in any estimate of the possibilities of either home or foreign markets. Even in a country so diversified as ours in its natural bounties, domestic production of everything consumed is not desirable nor profitable. Exchange of commodities with foreign countries becomes necessary: for instance, just as soon as America can mine and smelt copper or produce and refine petroleum more cheaply than it can grow tea or raise sheep or cattle, then the home market for cheap meat and wool and tea necessitates a foreign market for our copper and oil. Of course, the more we as a people are independent of goods sent from other countries the less are we dependent on a foreign market for our own products. Large imports necessitate large exports, else the balance of trade will swing too far on the wrong side.

So it follows that in planning industrial development independence is the goal toward which a nation should face, but not a goal which it should have either the intention or the desire to attain. As we look toward the South, we find that our commerce with South America for the last 4 years has been one-sided to the extent of an unfavorable annual trade balance averaging more than $80,000,000. The fact that the balance of trade is against the United States in two of the three "A B C" countries should be taken only as an invitation to export more. That $80,000,000 not only measures the present opportunity for exports to South America but also suggests the chance for further development of trade relations. We need meat and hides from Argentina, tin ore from Bolivia, rubber and coffee from Brazil, nitrate from Chile, platinum from Colombia, cacoa from Ecuador, wool from Peru and Uruguay, and coffee from Venezuela—what can we export in exchange?

The three deficiencies in America's supplies of mineral, suggested above, constitute a large part of the list of minerals absent or of rare occurrence in this country, yet a longer list would include other minerals which hitherto have been bought with apparent advantage from foreign producers. Under present conditions there has been some readjustment of the domestic mineral industries, resulting in the development of American substitutes for imported material. Sales of domestic manganese ores have been made to the glass trade, and production of ferromanganese on the Pacific coast is reported. The manufacture of zinc dust has followed the shutting off of the foreign supply, and barytes from the South has begun to replace the German imports. Medicinal oils derived from American crude oil have been placed on the market by several refining companies and advertised as equal in every particular to the Russian product. Several firms have expressed their intention of manufacturing magnesium chloride from California magnesite, of which at least one shipment has been made to the East and others are to follow by way of the Panama Canal. In the western states an efficient substitute has been found for the Danish flint pebbles used in the tube mills. In California river pebbles of quartz are used and in Idaho and Nevada pebbles are manufactured from local rock, and the mill men report that these cheaper substitutes are giving satisfaction.

Two separate lines of inquiry must necessarily be followed by anyone who is interested in industrial America: He must have at hand an inventory of our own mineral reserves, so as to determine their availability both as to location and character, and he must know the extent of foreign production and its controlling conditions and future possibilities. The present status and future prospects of American mining properly form a subject of governmental investigation, and are presented in the annual

report, "Mineral Resources of the United States," and the world view of the same subject is presented in this volume, "MINERAL INDUSTRY." These two publications have been issued annually since 1882 and 1892, respectively, but at no time has it been more important to study the subject from both points of view.

Not only is our country a world leader in the output of such essential minerals as coal, petroleum, copper, zinc, iron, lead, phosphate—and in the production of three of these it exceeds all other countries put together—but so far as such things can be measured or estimated we are blest in the possession of the largest reserves of many of these minerals. No other country can in any sense compare with the United States in the degree of industrial independence afforded by these mineral resources.

The export trade of the United States in crude minerals, whether fuels or metals, promises to expand greatly. Too much emphasis can hardly be placed upon America's strategic position in the possession of large reserves of coal. Not only does the United States mine 40 per cent. of the world's output of coal, but our coal tonnage in the ground is one-half the known reserves of the world. In considering fuel and its bearing on industrial opportunity hardly too much emphasis can be placed upon the distribution of the world's coal. Significant facts are that 98 per cent. of the world's production is mined in the northern hemisphere, and that of known reserves of coal of all grades the southern hemisphere possesses only 3.5 per cent. So, too, not only does the United States mine and consume 40 per cent. of the world's annual output of coal, but this country alone possesses five times as great a tonnage of unmined coal as the whole of Europe, and more than 1500 times as much coal as is known to exist in South America. Thus, the raw material is at hand to enable this country to win and maintain supremacy as a manufacturing nation.

Yet, with all these reserves of mineral wealth and apparent resultant advantages, the United States will profit by the readjustments already in progress only as the engineers who direct the mineral industries and the manufacturers who work up the raw material win and hold both the home and the foreign markets by superiority of product. The buyer, whether he be at home, or in the far East, or in South America, wants the most and best for his money. Ignorance of possibilities of production in other lands means a voluntary business hazard for which there is little excuse. The opportunity for expansion of business demands a world view of the situation.

ABRASIVES

Artificial Aluminous Abrasives

By L. E. Saunders

Alundum.—The production of various grades of alundum by Norton Co. in 1914 broke all records, being 21,839,090 lb., the rate of increase for 10 years and the value being shown in the accompanying table;

Year.	Pounds.	Value.	Year.	Pounds.	Value.
1904	4,020,000	$281,400	1910	13,410,000	$804,600
1905	3,612,000	252,840	1911	11,116,000	666,960
1906	4,331,233	303,186	1912	13,266,486	795,989
1907	6,751,444	405,086	1913	20,203,600	1,212,216
1908	3,160,000	189,600	1914	21,839,090	1,310,345
1909	13,578,000	814,680			

No revolutionary changes have taken place in the manufacture of aluminous abrasives during the past year, with the possible exception of the introduction of minor quantities of impure material from several European sources, placed on the market under various local trade names by users in this country.

Alundum is made in several grades to suit wide commercial applications; for that reason no typical analyses can be given. The range of alumina content is from 94 to 99.5 per cent., the impurities being those found in mineral bauxite, *i.e.*, silica, iron and titanium oxides.

The bauxite ore used comes from Saline County, Arkansas, and very strict requirements are maintained under Norton Company control. Before fusion in the electric furnace, water to the extent of over 30 per cent. is driven off in a rotary gas-fired kiln such as is used in cement manufacture.

The furnace used is a water-cooled one patented by A. C. Higgins, of Norton Company, and is intermittent in operation. When a complete charge is finished, the furnace is shut down, the sides stripped off and the ingot, weighing over 5 tons, allowed to cool slowly. This work is done at the Niagara Falls works and the product is shipped in lump form to the grinding wheel works at Worcester, Mass., where all finished articles are made and sold.

The product is now considered by competent authorities to consist essentially of alumina crystals, the impurities present not being integral

components of the crystals. This is strikingly shown by the facility with which the impurities may be removed from finely powdered samples by various chemical treatments. As has been indicated, the chemical composition is under control and is varied to produce modified physical characteristics now becoming necessary on account of the more exact knowledge of grinding operations on the part of the commercial user.

The chief use of alundum is in grinding materials of high tensile strength, steel pre-eminently. As by far the larger part of the pig iron produced in the world is converted into steel, and as much more steel than cast iron is sold with finished surfaces, the reason for the larger use of alundum over other artificial abrasives is at once apparent.

Abrasive wheels are made by the vitrified process or with a porcelain bond uniting the abrasive particles, as well as with organic binding materials of various compositions.

Alundum is prepared in the grain form of the usual sizes and is used for making abrasive paper and for polishing metals and other articles.

One of the most perplexing problems in connection with the use of the natural abrasives, emery and corundum, has been the sudden and wide variation in composition of different shipments. When it is known that, when desired, alundum can be duplicated year after year with practically no variation, it is seen that grinding wheel duplication is an easy matter.

An interesting development late in the year 1914 was the use of the grinding wheel in the finishing operations on large and small projectiles. The European war made large demands for this class of work, and as such articles are made of steel of high quality, the field developed rapidly for alundum.

In addition to abrasive uses, alundum has become well known as a laboratory refractory. The physical properties of the purer forms make alundum of value for making crucibles, tubes, muffles, electric furnace parts, and in the form of cement for building up shapes of any form. The method chiefly used is to mix the finely divided particles with a small amount of porcelain bond, mould the articles in the desired form and burn them in a kiln. The degree of porosity can be varied, and thus filtering mediums may be prepared. The bonded articles will withstand temperatures of about 1800° C. without distortion unless extreme density is desired. Pyrometer tubes for use with rare and base metal thermocouples are made and they have been found superior to fused silica and porcelain tubes for this purpose. The high thermal conductivity which this material possesses is a reason for excellence in all cases where it is desired to apply heat from an outside source to be transmitted through a diaphragm or wall made of it.

Corundum and Emery

By J. Volney Lewis

For many years abrasive corundum was mined in North Carolina and Georgia, and to a smaller extent in Montana, while emery was produced at Chester, Mass., and in the vicinity of Peekskill, N. Y. However, since the development of high-grade artificial abrasives and the exploitation of the larger corundum deposits in Ontario, there has been a steady decline in the mining of corundum and emery in the United States. No corundum has been produced since 1906, no emery has been reported from the Chester mines since 1912, and from the Peekskill district—never developed systematically or on a large scale—there is only a small, irregular production of variable quality. The only other natural abrasive that may fairly be classed with corundum and emery on the ground of its applications is garnet, the domestic production of which has ranged between 2000 and 7000 tons during the past decade, with an annual average of about 4500 tons.

Hence, almost the whole supply of abrasives in the United States for many years past has come from imports and from artificial products. Among the former the chief source is emery from Asiatic Turkey, with smaller amounts from Naxos, in the Grecian Archipelago. Corundum has come mainly from Canada, and in recent years in increasing amounts from India. Among artificial products most extensively used are silicon carbide ("carborundum," "crystolon") and artificial corundum, Al_2O_3 ("alundum," "aloxite").

The following table shows approximately the relative importance of the various natural and artificial abrasives in the United States during the past 10 years.

NATURAL AND ARTIFICIAL ABRASIVES IN THE UNITED STATES, 1905–1914[1]
(Short tons)

	Domestic.		Imported Emery and Corundum.	Total Mineral Abrasive.	Alundum, etc.	Carborundum, etc.	Total Artificial.	Per Cent. Artificial.
	Garnet.	Emery and Corundum.						
1905.....	5,050	2,126	14,007	21,183	1,806	2,798	4,604	17.8
1906.....	4,650	1,160	17,829	23,639	2,166	3,113	5,279	18.3
1907.....	7,058	1,069	14,724	22,851	3,376	3,766	7,142	23.8
1908.....	1,996	669	9,922	12,587	1,580	2,454	4,034	24.3
1909.....	2,972	1,580	12,364	16,916	6,789	3,239	10,028	37.2
1910.....	3,814	1,028	33,576	38,418	6,705	5,354	12,059	23.4
1911.....	4,076	659	12,878	17,613	5,558	5,188	10,746	37.9
1912.....	4,947	992	19,425	25,364	6,633	6,021	12,654	33.3
1913.....	5,308	957	20,425	26,690	11,309	6,299	17,608	39.8
1914.....	4,026	.....	14,457	.....	(e)12,200	5,411	17,600	.....

[1] Natural Abrasives, U. S. Geol. Surv.; Artificial, Mineral Industry. All calculated to short tons for comparison.

While the above table does not furnish a basis for rigid comparison between the natural and artificial abrasives used in the United States, it is a sufficiently close approximation to show clearly the decline in domestic corundum and emery, the large but somewhat variable imports, and the rapid gains of the artificial materials in the past 10 years. The statistics are subject to minor corrections for purposes of exact comparison, but several of these tend to neutralize each other. Thus: (1) a part of the domestic materials, both natural and artificial, are exported every year, chiefly in manufactured form; (2) similar manufactures are also imported, but not included in the above table; (3) some artificial abrasives are imported, and in increasing amounts in recent years; (4) some of the emery is used in the manufacture of aloxite; (5) a small but increasing proportion of the artificial materials is used for refractory purposes; (6) a small amount of quartz that is used for purposes comparable to those of corundum and emery should be added to the total of natural abrasives.

Canada.—The corundum mines are located in Renfrew and Hastings Counties, Ontario, and are operated by the Manufacturers Corundum Co., Ltd. The corundum is found as crystals embedded in a syenitic rock, from which they are separated by crushing and concentration, and the finished product is graded according to the size of grains. Production during the past 5 years is shown in the following table, which has been compiled from the reports of the Ontario Bureau of Mines (1910–13) and the Canadian Department of Mines (1914):

PRODUCTION OF CORUNDUM IN CANADA, 1910–1914

	Tons.	Value.	Per Ton.
1910	1,870	$171,994	$91.98
1911	1,471	147,158	100.04
1912	1,960	233,212	119.00
1913	1,177	137,036	116.42
1914	548	72,176	131.71

In the earlier years of the industry, 1901–03, the average recovery of grain corundum was 10 per cent. of the rock treated. In more recent years, however, a much lower grade of rock has been milled and the percentage of recovery has ranged from 3.9 to 6.4, with a 10-year average of 5 per cent.

India.—Corundum is mined in the state of Mysore and exported from Madras. The state of the industry is indicated by the following extracts from a letter from Dr. W. F. Smeeth, State Geologist, Bangalore, Mysore, India (*Commerce Reports*, Mar. 1, 1915):

"For the past few years from 100 to 200 tons of uncleaned corundum has been produced annually in Mysore. This is either loose surface

material, which is fairly clean, or material separated from decomposed rock by pounding with wooden mallets, which usually has a certain amount of softer material adhering to it. This material is collected by various licensees who work rather irregularly, and is usually sold to native dealers in Madras for export. It is a difficult matter to arrange with these people for a regular supply of anything like a standard grade. . . . In addition to the materials noted above, we have considerable quantities of hard rock containing corundum, which is not treated at present for want of suitable plant."

Dr. Smeeth proposes the establishment of a governmental agency for the purchase, cleaning, and grading of the material.

South Australia.—Corundum has been found in a dark mica schist in the rough ranges between Lake Eyre and Frome. The region is 2000 to 3000 ft. above sea level, is rugged and stony, and intersected by deep gorges. The corundum occurs in rough hexagonal crystals and small disseminated pieces of blue, white, greenish, and mottled colors, and in some places constitutes 10 to 25 per cent. of the rock, according to the Government Geologist.

Greece.—The export of emery during 1913 amounted to 1440 metric tons, valued at $30,650, as against 7687 metric tons, valued at $163,745, during 1912. During nearly the whole of 1913 the laborers were on strike and the mines were practically idle. The 1440 metric tons shipped were drawn from stocks in the government stores.[1]

A full description of the emery deposits of the Grecian islands, together with maps and text figures, including many geologic cross-sections, has recently been published,[2] of which the following is a partial summary: The emery occurs in three zones, the lowest of which is always granular and free from chloritoid and corundum; the uppermost contains chloritoid in noticeable amounts as vein fillings with blue corundum, while the middle emery has mixed characteristics. All three of these types occur on the island of Naxos, while Iraklia and Sikinos contain only the last. Crevices in the emery contain margarite mixed with muscovite, tourmaline, pyrite, magnetite, hematite, chlorite, and talc; and less frequently diaspore, cyanite, limonite, and calcite; very seldom biotite, rutile, and quartz, besides kaolin-like decomposition products. The secondary formation of margarite from corundum or diaspore is often evident. Many analyses and tests for determining the hardness and cutting value are given.

From its mode of occurrence, characteristics, and composition, the author interprets the origin of these emery deposits and those of Asia Minor as follows: During the pneumatolytic period of the deeper granite

[1] *Mining Journal*, June 13, 1914.

[2] S. A. Papavasiliou: Die Smirgellagerstätten von Naxos nebst denjenigen von Iraklia und Sikinos, *Zeits. d. deutsch. geol. Ges.*, **65**, 1–123, 1913–14.

intrusions, vapors and superheated waters carrying an excess of aluminium and iron, possibly as fluorides, penetrated between the layers of the limestone and replaced calcium. The resulting carbonates of aluminium and iron changed into oxides and finally formed emery. As the heated solutions receded from the granite their physical and chemical properties changed until they finally became hot springs. As fumarole activity continued the lower emery underwent extensive hydration and redeposition, resulting in the formation of diaspore and other derivatives.

Imports.—There was a decline of more than 25 per cent. in the imports of corundum and emery in 1914, as compared with the preceding year. Only the minor item of wheels, files, and other manufactures showed an increase. In the second half of the year there was a falling off of imports of more than 50 per cent. as compared with the first half, as shown in the following table:

IMPORTS OF CORUNDUM AND EMERY IN 1914

	Corundum.		Emery.		Total (Long Tons).
	Ore (Long Tons).	Grains (Lb.).	Ore (Long Tons).	Grains (Lb.).	
First half-year	178	506,265	8,739	418,151	9,330
Second half-year	68	513,882	3,923	343,523	4,373
Total	246	1,120,147	12,662	761,674	13,703

For many years the great bulk of the emery supply has come from Asiatic Turkey and most of the corundum from Canada. The principal Turkish mines are 50 to 200 miles southeast of Smyrna. The cost of working has increased at the nearer ones with increasing depth, while from the more remote districts the ore has to be brought to market on camels and, to a less extent, on donkeys and mules.

The following table gives the quantity and value of corundum and emery imported into the United States during the past 10 years:

IMPORTS OF CORUNDUM AND EMERY, 1906–1914[1]

	Grains.		Ore and Rock.		Manufactures, Value.	Total Value.
	Pounds.	Value.	Long Tons.	Value.		
1905	3,209,915	$143,729	11,073	$185,689	$18,007	$347,425
1906	4,655,668	215,357	13,841	286,386	19,339	521,082
1907	4,282,228	186,156	11,235	211,192	15,282	412,630
1908	1,735,366	89,702	8,084	146,105	15,592	248,399
1909	2,696,960	132,264	9,836	186,930	19,803	338,997
1910	2,311,464	106,570	28,948	509,661	13,527	629,758
1911	1,382,813	76,027	10,822	245,459	15,158	336,644
1912	2,135,922	105,325	16,391	369,529	16,871	491,725
1913	2,496,372	114,786	17,123	342,809	16,704	474,299
1914	1,781,821	79,989	12,909	280,876	22,581	383,446

[1] Statistics for 1905–1913 from the U. S. Geological Survey; for 1914 from Bureau of Foreign and Domestic Commerce.

In addition to the natural abrasives included in the foregoing table, artificial abrasives were imported in 1914 to the value of $170,749, representing perhaps about 1500 tons.

GARNET

By D. H. NEWLAND

The Adirondack garnet mines, which yield the greater part of the mineral sold for abrasive uses, were operated last year on about the usual scale. The output of hand-sorted garnet and mill concentrates amounted to 4026 short tons, valued at $134,940, which is a little less than in 1913 but about the average product for recent years. Prices were unchanged, the best grade of crystal garnet bringing $35 a ton, the standard which has prevailed for a long time, with considerable reductions, however, for massive garnet and the finer sizes. No new operations have been undertaken during the year, and under present conditions there is no incentive for the establishment of additional enterprises in this region. The output for the product is strictly limited, as may be inferred from the statistics of production which for the last decade or more have shown no marked increase, although the Adirondack mines alone are capable of supplying twice their present output without much addition to their equipment.

The Adirondack deposits have been described in the earlier volumes of MINERAL INDUSTRY, notably in Vols. 6 and 21, and little may be added to those descriptions. In brief, they consist of certain zones or bands of the country rocks, both gneisses and massive rocks, which contain disseminated crystals and aggregates of garnet in unusual abundance. The garnet is the variety almandite, one of the harder sorts, with a reddish color. In some places, as instanced by the Rogers mine on Gore Mountain, the garnet forms imperfectly bounded crystals and crystal masses up to a ton in weight, but elsewhere it rarely occurs in individuals of more than an inch or two in diameter. In one of the occurrences at least the garnet has no crystal development, but appears to be massive, lacking also the characteristic parting which the crystal garnet possesses.

The mines are open-cut workings and the garnet is obtained by hand work or by crushing and concentration. The former method is practised on Gore Mountain, where the conditions are unusual both in regard to the size and abundance of the crystals. Mechanical separation is used by the North River Garnet Co., whose mines are on Thirteenth Lake, and by the Warren County Garnet Mills, at Wevertown. Owing to the presence of hornblende in the country rock the separation requires rather careful work, as there is less than a unit difference in the specific gravity

of hornblende and garnet. A combination of wet methods and pneumatic jigs is employed and gives a good clean garnet concentrate.

Imports.—In addition to the domestic supply this country consumes a considerable quantity of foreign garnet, which made its first appearance in the market about 5 years ago. It comes from the province of Almeria, Spain, where it is obtained by washing alluvial sands. The garnet is an inferior grade and is supplied in the finer sizes only, so that it has not been a strong competitor of the American product. The imports of Spanish garnet in 1914 amounted to 1244 short tons, with a declared value of $20,277, as compared with 547 short tons, valued at $8078, in 1913.

PRODUCTION OF ABRASIVE GARNET (*a*)
(Short tons.)

Year.	Quantity.	Value.	Year.	Quantity.	Value.
1903	3,950	$132,500	1909	2,972	$ 102,315
1904	3,854	117,581	1910	3,814	113,564
1905	5,050	148,095	1911	4,076	121,748
1906	4,650	156,000	1912	4,947	163,237
1907	7,058	211,680	1913	5,308	183,422
1908	1,960	64,620	1914 (*b*)	4,026	134,940

(*a*) U. S. Geological Survey.
(*b*) New York alone.

Silicon Carbide

There have been no developments of importance in the silicon carbide industry during the past year, either as regards the extension of plants or developments in technology. The only producer in the United States is the Carborundum Co., at Niagara Falls. The 1914 production amounted to 10,821,530 lb., valued at $595,184, as compared with 12,597,590 lb., valued at $692,867. The decreased production was due to depressed business conditions which continued throughout the year. The production of silicon carbide in most foreign plants was likewise curtailed. The plant at Arendal, Norway, is reported to have been closed since the beginning of the war. The plant at La Bathe, France, being of Austrian ownership, was sequestered by the French Government. In Canada, the Norton Co. at Chippawa, Ont., has been in regular operation, and the Exolon Co. at Thorold, Ont., started in operation the latter part of October. The production of the Norton Co. was 3,100,000 lb., valued at $279,000. This is shipped in bulk to Worcester, Mass., where it is made up into finished articles.

PRODUCTION OF CARBORUNDUM IN THE UNITED STATES.

Year.	Pounds.	Metric Tons.	Value.
1892	2,145	1	.....
1893	15,200	7	.....
1894	52,190	24	.....
1895	225,930	102	.....
1896	1,190,600	540	$365,612
1897	1,242,929	564	153,812
1898	1,594,152	724	151,444
1899	1,741,245	791	156,712
1900	2,401,000	1,089	168,070
1901	3,838,175	1,742	268,672
1902	3,741,500	1,698	261,905
1903	4,760,000	2,160	333,200
1904	7,060,380	3,203	494,227
1905	5,596,280	2,539	391,740
1906	6,225,280	2,824	435,770
1907	7,532,670	3,418	451,960
1908	4,907,170	2,226	294,430
1909	6,478,290	2,938	388,697
1910	10,707,110	4,857	642,427
1911	10,376,620	4,707	622,597
1912	12,042,550	5,464	722,553
1913	12,597,590	5,717	692,867
1914	10,821,530	4,910	595,184

ALUMINIUM AND BAUXITE

ALUMINIUM

By J. W. Richards

The aluminium industry progressed normally in 1914 until the outbreak of the European war, the beginning of August. Since that period the American works have been in regular operation, unaffected by the war. Information as to the European plants is fragmentary and unreliable. It is estimated that the output of Europe decreased to below that of 1913, and in the following tables a reduction of output of most of the European works of 20 per cent. below that of 1913 has been assumed. Upon that basis, and an estimated figure for the production of the United States, and an approximate figure for Canada, based upon its exports during 1914, the following estimate can be made of the world's production:

Country.	Metric Tons.	Pounds.
United States	42,270	93,000,000
Canada	6,820	15,000,000
France	12,000	26,400,000
Great Britain	8,000	17,600,000
Norway	2,500	5,500,000
Switzerland	10,000	22,000,000
Austria Hungary	4,000	8,800,000
Italy	800	1,700,000
	86,390	190,000,000

Grouped by producers these figures would be

	Metric Tons.	Pounds.
Aluminum Co. of America, Northern Aluminum Co. of Canada	49,090	108,000,000
L'Aluminium Francais	13,500	29,700,000
British Aluminium Co	9,000	19,800,000
Aluminium Industrie Aktien Gesellschaft	14,000	30,800,000
Societe D'Aluminio, Italy	800	1,700,000

The estimated increase of output, referred to in Mineral Industry, 22, 13, was not put in operation in 1914 because of the disturbance of business conditions. If, however, the European war terminates in 1915, it is altogether probable that increases of production of the following amounts will be made in 1916:

	Metric Tons.	Pounds.
Aluminum Co. of America will be increased by	18,000	39,600,000
Southern Aluminium Co. will be increased by	12,000	26,400,000
Swiss Aluminium Co. will be increased by	13,000	28,600,000
	43,000	94,600,000

Imports of aluminium into the United States in 1914 were 7382 metric tons (16,241,340 lb.) valued at $2,729,383; manufactured goods to the value of $1,308,036. Exports were made to the value of $1,546,510. The visible supply of crude metal in the United States in 1914 totals 49,655 metric tons (109,241,000 lb.). There were considerable amounts of crude aluminium in stock, unsold at the end of the year, so that the consumption of aluminium in the United States during 1914 probably approximated 50,000 metric tons or 110,000,000 lb.

The sharp increase in aluminium production continued in 1914, in spite of the unfavorable war conditions; prospects are that it will continue in 1915, but predictions are necessarily more uncertain this year than usual.

PRODUCTION, IMPORTS AND VISIBLE SUPPLY OF ALUMINIUM IN THE UNITED STATES

	Production.			Imports.			Exports.	Visible Supply. (b)
				Crude.		Mfrs.		
	Pounds.	Value.	Per Pound.	Pounds.	Value.	Value.	Value.	Pounds.
1900..	7,150,000	$2,288,000	$0.32	256,559	$44,455	$5,989	$281,821	7,407,000
1901..	7,150,000	2,238,000	0.31	564,803	104,168	5,580	183,579	7,715,000
1902..	7,300,000	2,284,590	0.31	745,217	215,032	3,819	116,052	8,045,000
1903..	7,500,000	2,325,000	0.31	498,655	139,298	4,273	157,187	8,000,000
1904..	7,700,000	2,233,000	0.29	515,416	128,350	478	166,876	8,216,000
1905..	11,350,000	3,632,000	0.32	530,429	106,108	33	290,777	11,880,000
1906..	14,350,000	5,166,000	0.36	770,713	154,292	1,866	364,251	15,121,000
1907..	26,000,000	10,920,000	0.42	872,474	181,351	1,124	304,938	26,872,000
1908..	13,000,000	4,095,000	0.315	465,317	80,268	2,334	330,092	13,465,000
1909..	15,000,000	3,345,000	0.223	5,109,843	745,963	12,878	567,375	20,110,000
1910.	12,000,000	2,736,000	0.228	12,271,277	1,844,830	.....	949,215	24,271,000
1911..	(c)28,600,000	5,720,000	0.20	(d)4,173,308	598,272	(d)63,899	1,158,603	32,773,000
1912..	(c)40,000,000	9,200,000	0.23	22,759,937	3,092,889	428,182	1,347,621	62,760,000
1913..	(c)64,900,000	13,600,000	0.21	23,185,755	3,905,977	1,090,229	966,094	88,086,000
1914..	(c)93,000,000	17,298,000	0.186	16,241,340	2,729,383	1,308,036	1,546,510	109,241,000

(a) Not reported. (b) Production plus imports. (d) From July 1 only. (c) Estimated.

MARKET PRICES

The average market price of first quality aluminium varied in New York during 1914 as follows:

January	18.81 cts.	July	17.66 cts.
February	18.81	August	19.88
March	18.50	September	19.94
April	18.16	October	18.50
May	17.95	November	18.00
June	17.75	December	18.96

Average price for year, 18.63 cts.

The average value in 1913 was 23.64, showing a reduction of practically 5 cts. per lb. The average value of imported aluminium in 1914 is given by the Bureau of Foreign and Domestic Commerce as 16.8 cts. per lb., which does not include the duty of 3 cts. per lb. to be paid on entry. Prices in Europe averaged 15.5 cts. per lb. during the first half of the year, but were very unsettled and in most countries 50 to 100 per cent. higher than this during the last five months of the year, owing to the war conditions.

The estimated 15,000,000-lb. output for Canada is based on the fact that exports from Canada were 14,510,800 lb. of ingot, bars, etc., and since part of the output of the Canadian works must have been consumed in Canada, 15,000,000 lb. is a conservative estimate of the output. Imports into Canada during 1914 were 3,796,353 lb., valued at $745,855, or an average price of 19.5 cts. per lb. The consumption of aluminium in Canada was therefore probably over 4,300,000 lb. in 1914. (From advance figures kindly furnished by the Canadian Department of Mines, Division of Mineral Resources and Statistics.)

Charles M. Hall.—The aluminium industry in America lost its leading spirit when Mr. Hall died on December 27. In 1886, while experimenting as a post-graduate student at Oberlin College, he discovered the solubility of alumina in melted cryolite and the possibility of electrolytically decomposing such a solution. Persevering through several years of discouragement, he lived to see his process the basis of a huge industry. From $5 a lb., when he started, the market price of aluminium has been reduced to 18 cts.; from an output of 40 tons a year it increased to over forty thousand. Although a great sufferer for several years, yet he kept his mind on the various details of a large business until the end; though feeble, one could say that he died in harness. He had the characteristics of an inventive genius: original and unusual ideas, which he tested out with great perseverance and mechanical skill. He has left behind a well-organized and active corporation, controlled by technical men who have absorbed and learned much of Mr. Hall's methods and ways of work by their long personal association with him. Thus will his spirit still continue to guide the industry to greater achievements.

Progress in Various Countries

United States.—The Aluminum Company of America started its plant at Maryville, Tennessee, which is operating at 20,000 h.p. and is intended to be extended to 50,000 when water power developments have been completed, in 1916. The Massena, N. Y., works of the same company is commencing to receive auxiliary power from the Cedar Rapids Power Station on the St. Lawrence, in Canada. The

aluminium cable transmission line is 45 miles long, and when working at full capacity will eventually transmit 85,000 h.p. to Massena. This company is starting construction work on a large plant at Edgewater, N. J., which will roll sheet and produce stamped and pressed ware, such as cooking utensils and like goods.

The Southern Aluminium Company discontinued its construction work toward the close of 1914, because of financial matters. D. M. Liddell[1] and C. Hafer[2] give detailed illustrated accounts of the present status of this great enterprise at Whitney, N. C. Most of these details were contained in the 1913 MINERAL INDUSTRY. A few new facts are the following: The dam on the Yadkin will give 33,600 average h.p. The total power available will be 70,000 kw. The reduction works will be 600 by 600 ft. Current will be used at 500 volts. The company will prepare alumina by the old Baeyer process and not by the Serpek process. The electrode building is 100 by 200 ft. The village for employees has been named Badin, after the president of the parent company—L' Aluminium Française. When in operation, 1200 to 1500 men will be employed. Rolling mills for wire, sheet and tubing will be built, also a plant for making alloys.

Scrap aluminium is becoming a considerable factor in the American market. It is estimated that between 2000 and 3000 tons a year of pure metal, and an equal quantity of light aluminium alloy, is regained and sold, to the value of over $2,000,000.

Germany.—This country produces no aluminium, but works up large quantities. In consumption of aluminium it ranks next to the United States. Germany has sold much scrap aluminium to Holland, Belgium and the United States; sheet, plates, etc., to Great Britain, India, Belgium, Switzerland, Italy and Russia; wire to Great Britain, Denmark and Switzerland; cooking utensils and general hardware fittings to Great Britain, India, Canada, Austria, Norway, Denmark, Holland, Belgium, Italy, Russia, Brazil and the United States. In many foreign markets the trade in manufactured aluminium articles appears to be almost wholly in German hands.[3]

Switzerland.—The *Journal du Four Electrique* of May 15, 1914, reports the annual meeting of the Aluminium Industrie Aktien Gesellschaft, in Zurich, April 21, 1914. In 25 years this company has expended $12,400,000 for construction, and has distributed $6,300,000 in dividends, the mean annual dividend for 25 years being 15.2 per cent. The 1914 dividend was 20 per cent.

Great Britain.—The British Aluminium Co., Ltd., held its annual

[1] *Eng. Min. Jour.*, June 13, 1914.
[2] *Min.Eng. World*, Jan. 16, 1915.
[3] British Board of Trade, White Paper No. 77.

meeting on March 27, 1914. The net income for the fiscal year was given as £268,720. This company has increased the capacity of its plant at Vijeland, Norway. The company is rapidly increasing the capacity of its British works. A new alumina factory is to be built at Burntisland, Scotland. New mills for working the metal have been erected at Warrington, Lancashire. The profits allowed paying full dividend on the preferred stock and 5 per cent. on the ordinary shares of the company.

India.—U. S. Consul General J. A. Smith, at Calcutta, states that aluminium imported into India as ingots and sheets reaches 1800 tons per year, about half of which is from Germany and one-quarter each from Great Britain and the United States. The principal factories are at Madras and Bombay. The demand for the wares is increasing more rapidly than the local factories can supply. Bauxite is found in Balaghat and Jubbelpore, and the field for a local aluminium-producing plant is very promising.

Aluminium Nitride

Aluminium nitride, as proposed by the Serpek process, continues to interest scientists, but has attained no commercial standing, in the year 1914. C. Matignon[1] determines the heat of formation of AlN as 55,000 Cal., thus showing it to be a relatively stable compound. J. Wolf[2] finds AlN to decompose slightly at 1850° C. and rapidly at 2150° to 2200° C. To be produced commercially, it must be made below 1900° C. Pure nitrogen is more favorable to its production than producer gas, but also more costly. The process of Serpek may be said to still have commercial possibilities, but a great deal of expensive experimenting is still needed to realize them.

Properties of Aluminium

Composition.—Bordel and Boulanger report that European commercial aluminium contains 0.02 per cent. of the rare metal gallium.[3]

Specific Gravity.—F. C. A. H. Lantsberry finds that the density is increased 0.13 by cold working.[4] Paul Pascal[5] determined the density of melted aluminium. The metal used contained Al 99.46, Fe 0.19, Si 0.27 per cent., C not determined, Cu traces; density at 15° C. 2.794, annealed at 610° C. 2.781. The liquid metal commences to act upon fused quartz at 900° C., producing a thin black crust of silicon. The density of the liquid metal decreases lineally with the temperature; or

[1] *Chemiker Ztg.*, **38**, 894 and 909.
[2] *Zeit. für anorg. Chem.*, **87**, 120 (1914).
[3] *Brass World*, Feb., 1914.
[4] *Jour. Inst. of Metals*, **12**, 274 (1914).
[5] *Rev. de Metallurgie*, p. 475, May, 1914.

its specific volume increases lineally with the temperature. The experimental results are tabulated under "*Specific Gravity of the Bath.*"

Specific Heat.—P. N. Laschtenko[1] used metal containing 0.31 silicon, 0.63 iron, but free from copper and lead. The specific heat increases rapidly between 580° and 590° C. The latent heat of fusion at 657° C. was 71 Calories.

Nernst and Schwers[2] get the following values at very low temperatures:

T (Absolute)	t (C. °)	Sp. Heat
19.1	−253.9	0.0024
52.4	−220.6	0.0410
79.1	−193.9	0.0872

Surface Tension.—Smith[3] obtained the following data, between 700° and 820° C.: Specific gravity 2.35; capillary constant ($rh = a^2$) 45.09; surface tension (dynes per cm.) 520.

Boiling Point.—Greenwood gives the boiling point as 1800° C.; von Wartenburg as over 2200° C. The latter is probably the more reliable figure.

Electric Conductivity.—G. Geivecke[4] found that annealing hard-drawn aluminium wire 15 to 120 min. at 160° C. increased its conductivity 1.16 to 2.94 per cent.; at 270° C., 6.61 to 6.94 per cent. The tensile strength is lowered by the annealing, making the wire unsuitable for long spans, but there are other places where this increase may be useful.

Resistance to Corrosion.—W. P. Torisson[5] states that distilled water has very little action, but ordinary water may pit the metal even in the absence of air. Cold-worked aluminium corrodes locally; annealing at 540° C. stops local corrosion by relieving the strains due to working. Solutions of salt and sea-water produce strong local corrosion. Amalgamated aluminium dissolves freely in sulphuric acid. I. Vogelsanger[6] treats the metal as anode in boiling solution of alum, borax and caustic soda; it is then dipped into nitric acid and afterward into lime water. Thus treated it is said not to corrode in the weather or in organic acids.

Reduction to Metal

Reduction Pots.—The plant of the Southern Aluminium Company at Whitney, N. C., will contain iron pots 5 by 9 by 12 ft. outside measurement. These will have one layer of fire-brick inside, next to the iron shell, and then the carbon lining. The interior working cavity will be 4 by 8 ft. by 20 in. deep. Each furnace will take 20,000 amp. at 7 volts

[1] *Jour. Chem. Soc.* (2), p. 427, June, 1914.
[2] *Jour. Inst. of Metals*, 12, 280 (1914).
[3] *Jour. Inst. of Metals*, 12, 168 (1914).
[4] *Zeit. d. Vereins deutsche Ing.*, 1914.
[5] *Engineering*, p. 512, Oct., 1914.
[6] German Patent 272043.

(140 kw.) and should produce 300 lb. (135 kg.) of metal per day. With a line potential of 500 volts, 70 pots will be run in series. There will be six such units, or about 400 pots in running at once, giving a maximum yearly output of 44,000,000 lb. (20,000 metric tons).

Engineering and Mining Journal of July 25, 1914, describes the modern aluminium reduction pots as 6.5 to 13 ft. long, 4 to 5 ft. wide, and 2 to 2.5 ft. deep. The iron shell is reinforced with angle irons, and has a tap-hole at the center of one end. They are inclined when tapping. Bars of iron buried in the carbon lining make good connection with the outer shell when a layer of refractory material is used. The carbon anodes are made from petroleum coke containing less than 1.5 per cent. of ash. The normal running potential is 8 volts per pot. It takes 2 days to get a pot warmed up to its work.

Specific Gravity of the Bath.—Pascal and Junieux[1] determined the specific gravities of aluminium and melted bath material of various compositions at various temperatures. Their results on pure aluminium and cryolite are as follows:

Temperature.	Cryolite.	Aluminium.	Temperature.	Cryolite.	Aluminium.
15° C.	2.97	2.79	972	2.18 (solid)	.....
658	.....	2.46	977	2.20 (melting)	.....
682	.....	2.45	995	2.22	.....
740	.....	2.43	1000	2.21	2.35 (extrapolated)
802	.....	2.41	1018	2.20	.....
868	.....	2.39	1061	2.15	.....
925	.....	2.37	1083	2.10	.....
			1100	2.07	2.32 (extrapolated)

These results show a maximum of 2.22 at 995°, being 0.13 below the density of aluminium at the same temperature. Silica diminishes the density of cryolite, 3 per cent. reducing it by 0.05.

Fluorspar increases rapidly the density of melted cryolite. In general, 12 per cent. of fluorspar and 88 per cent. of cryolite has a specific gravity 0.10 higher than pure cryolite; 25 per cent. fluorspar and 75 per cent. cryolite a density of 0.26 higher than cryolite, and is even higher than that of aluminium from 900° to 1150° C.

The addition of alumina to cryolite reduces the specific gravity when in quantities below 20 per cent., 5 per cent. of alumina giving a maximum density of 2.14 at 970° C.; 10 per cent. of alumina a maximum density at 950° C., and 24 per cent. a maximum density of 2.26 at 935° C. This maximum density, however, is still below the density of aluminium at the corresponding temperatures.

Mixtures of cryolite, alumina and fluorspar have densities greater than the binary mixture of cryolite and alumina, for instance,

[1] *Bull. de. la Soc. Chimique*, p. 312, April 5, 1914.

Cryolite, Per Cent.	Alumina, Per Cent.	Fluorspar, Per Cent.	Temperature, ° C.	Maximum Density
81.82	9.09	9.09	985	2.22
71.00	17.75	11.25	1010	2.23
67.50	7.50	25.00	985	2.28
64.30	11.90	25.70	1010	2.31
59.30	17.70	23.00	1000	2.33
57.20	14.30	28.50	1000	2.39

With all the mixtures used in the aluminium industry the density of the bath is below 2.40 at 950°, the average working temperature of the bath. With the bath rich in fluorspar, the maximum density, as the temperature rises, may approach close to that of aluminium. One conclusion is that the alumina in the bath should not exceed 10 per cent. if the amount of fluorspar is high.

Melting Point of Bath.—W. A. McKnight has carefully determined the melting point of cryolite containing varying amounts of alumina, upon which Pyne and Pascal have published discordant results. His values are:

Cryolite, Per Cent.	Alumina, Per Cent.	Melting Point, ° C.
100.	.....	1000
97.5	2.5	985
94.9	5.1	969
89.2	10.8	950
86.1	13.9	940
84.5	15.5	935 (eutectic)
82.8	17.2	945
79.3	20.7	1000

Bath Tension.—Krause[1] states the necessary tension for running a bath with 7500 amp. is 6.05 volts, distributed about as follows:

From the bus-bar to the upper end of the anodes	0.40 volt
In the anodes	0.85 volt
In the lining of the pot	1.00 volt
Ohmic resistance of the bath	1.67 volts
Decomposition of the bath	2.13 volts
	6.05 volts

Output.—P. Askenasy states that the production in European plants is over 300 kg. (660 lb.) per kw.-year.

Direct Reduction.—G. Guilini[2] heats, under reduced pressure, a mixture of alumina and carbon to a temperature sufficient to distil the aluminium. This procedure is claimed to obviate the formation of aluminium carbide.

Granulating.—Bandberger and Jüptner discuss the explosions which have occurred when aluminium was being granulated by pouring into water. The latent heat of the metal is so high that 10 kg. (22 lb.) will

[1] Das Aluminium, Vienna, 1914, p. 80.
[2] French Patent 456290, 1913.

produce 1.4 kg. of steam, with a volume of 2.3 cu. meters (81 cu. ft.). This is sufficient to produce a violent explosion if generated too quickly.

Working and Uses

Plating with Nickel.—E. Tassilly[1] describes the following method of plating aluminium with nickel, which has been patented by J. C. Cannac.[2]

1. Dipping in boiling potash solution.
2. Coating with milk of lime.
3. Dipping in 0.2 per cent. bath of potassium cyanide for several minutes.
4. Dipping in a bath of 500 grams of water, 500 grams of hydrochloric acid and 1 gram of iron, the aluminium taking a black moire appearance.

After each dipping the piece is washed in water. The nickel plating is done in a bath containing, per liter, 50 grams of nickel chloride and 20 grams boric acid, using 2.5 volts; the current is about 1 amp. per sq. dm.

Photomicrographs of the plating show a perfect adherence of the iron to the aluminium and the nickel to the iron. The method is suggested as suitable for aluminium transmission lines, also for any places where the aluminium itself rapidly deteriorates.

"Brass World" states that while pure aluminium can not be successfully nickel plated, the alloy with 33 per cent. zinc, used so much in automobiles, can be electroplated with nickel by first brushing, then dipping in solution of mercury cyanide (¼ oz. yellow mercury oxide and 2½ oz. potassium cyanide and water, boil a few minutes, cool, and filter before using). Pass the alloy through this mercury dip, then flash with a good copper coating by dipping, and then it can be easily electroplated with any desired metal.

Coating Iron.—S. Uyens[3] passes galvanized iron or tinned iron through a bath of molten aluminium, rubbing it with brushes during its passage.

Spraying on Metals.—By the Schoop process, metallic aluminium as wire is fed into an oxy-coal-gas flame and atomized by compressed air. One pound of aluminium can thus be atomized and deposited at a working cost of about 60 cts.[4]

Calorizing of Metals.—Under this term, H. B. C. Allison and L. A. Hawkins describe[5] a modification of Van Aller's process of surface-coating

[1] *Revue de Metallurgie*, p. 670, June, 1914.
[2] *Comptes rendus*, **158**, 119 (1914).
[3] *Electrochem. Zeits.*, **20**, 354 (1914).
[4] V. Bernard, *Rev. de Metallurgie*, **10**, 1377 (1913).
[5] *Gen. Elec. Rev.*, Oct., 1914.

metals with aluminium. The latter consists in heating the articles with aluminium powder in revolving drums, whereby their surface is alloyed with aluminium and becomes more resistant to chemical corrosion. E. G. Gilson improved upon this by packing the articles in aluminium powder, or merely painting them with the powder, and heating them. Wire or ribbon may be continuously treated. This simple treatment makes the article very resistant to corrosion, particularly to oxidation at high temperatures. Seamless iron tubing thus treated can be used at 900° to 100° C. in pure oxygen, with a life of over 100 hr. Treated iron ribbon has been used as resistor in small electric furnaces, giving over 500 hr. service at 800° C. Such iron ribbon changes remarkably its electrical resistance and temperature coefficient by the treatment, as follows:

	Resistance in Ohms per Meter (19°)	Temperature Coefficient (0–150°)
Untreated ribbon	0.905	0.00561
Ribbon treated lightly	2.45	0.00172
Ribbon treated heavily	7.60	0.00015

Copper tubes thus treated are much more resistant to corrosion cold, as in condenser tubes, and also to oxidation when hot. Iron is protected against oxidation when heated, but not against corrosion cold. The probable explanation is that a thin layer of alumina forms on the surface, which prevents further penetration of the corroding agent.

Precipitation of Gold.—Chas. Butters[1] patents the use of granulated aluminium, instead of the more expensive aluminium dust, for precipitating gold (and silver) from cyanide solutions.

Electrical Conductors.—By the method of "extrusion," aluminium bus-bars of almost any desired length can be made in one piece, thus dispensing with the joints. For power transmission to long distances, aluminium stranded cable with steel core has such great advantages that its use is rapidly increasing. Taking a galvanized hard-drawn steel wire of 160,000 lb. tensile strength and 130,000 lb. elastic limit per sq. in., six aluminium wires of equal diameter are tightly twisted upon it. The hard-drawn aluminium has 24,000 lb. tensile strength and 13,000 lb. elastic limit per sq. in. The combination gives a cable having 80 per cent. of the weight of a pure copper cable of equal conducting power, but 57 per cent. stronger. With about equal cost of cable per mile, it is possible to place the towers so much farther apart that great savings result in cost of erection, towers, insulators and leakage of current.

Use in Steel Castings.—W. H. Wickhorst[2] quotes the reports of the

[1] U. S. Patent 1092765.
[2] *Iron Age*, April 30, 1914.

American R. R. Engineering Association's tests on rail steel. With 10 ounces of aluminium used per ton of steel the ingots piped badly; with small amounts the pipe was smaller; with 1 ounce the top was nearly flat, with a small pipe. Chemical analysis showed less segregation in the treated ingots; drop tests showed them to have greater ductility, with no brittle zone in the upper part.

Chemical Apparatus.—Large pans, retorts, digesters, etc., are autogenously welded for use in the manufacture of linseed oil, stearic acid, varnish, distillation industries, brewing, cooking, sugar refining, explosives, dyeing. It is stated that aluminium is suitable for practically all purposes if kept out of contact with hydrochloric acid, halide solutions or caustic alkalies.

In the brewing industry it is found to have no effect on the yeast cells, giving better product than copper vessels. It does not color or poison or affect the beer in any manner, and is recommended for fermenting tuns, yeast vats, stillions, tubes, wagons, pruning vessels, pitching pales, storage and rack tanks.

In the varnish industry it is found of high thermal conductivity, resistant to the fire gases and not acted upon by the varnish, insuring varnish of pale shades from good material.

In sugar refining bi-metallic tubes are being used, the outside being of copper and the inside of aluminium. Scale forming on the outside can be quickly removed by caustic potash, while the aluminium lining resists corrosion effects of ammonia present in the steam. Sieves and screens of aluminium are of increasing use.

Oil industries use aluminium in contact with fatty or vegetable oils and hot oleic, stearic and palmitic acids, for stills, condensing coils, wagons and tanks. It is also used in the soap and candle industries for the same reasons.

In the explosive industries it resists the combined or separate actions of sulphuric and nitric acids and is therefore extensively used for nitrating pans, grids and centrifugals. In dye works it is used in many parts of the plants for tanks and all sorts of apparatus. Aluminium is also used in the production of hydrogen peroxide, formaldehyde, citric acid and glycerine.[1]

Gas Industry.[2]—Used in gas lamps for outside casings, tops, reflectors and inner portions. Dents easier than copper or steel (should be made thicker). The chimneys do not chip, flake or rust, nor induce condensation when cooling. Products of combustion do not affect it, nor does the atmosphere corrode it badly.

[1] *Metal Industry*, 200; May, 1914, p. taken mostly from Bulletin No. 144 of the British Aluminium Co., Ltd.

[2] *Jour. Gas Lighting*, 128, 732 (1914); through *Jour. Ind. Eng. Chem.*, Mar., 1915, p. 255.

In a mantle works aluminium is used in machines for impregnating mantles. In 2 years the aluminium shows no corrosion.

It resists SO_2 and SO_3 gases and ammonia. Aluminium electrical conductors are very useful in and around gas works, coke plants, and producer plants, for power transmission, lighting circuits and telephones.

It is used in gas works for siphon pumps, tubes and mains. Corrugated sheeting is also very useful in place of corrugated galvanized iron. It also replaces brass parts in gas meters and may be used for taps and cocks when the right alloy to use is found.

Nitric Acid.—The huge Rjukan works in Norway, manufacturing nitric acid from the atmosphere, uses aluminium in large quantities. Their plant contains nearly 1000 tons of aluminium. It is used for gas mains, fans, buckets, scoops, shovels, vats, tanks, conducting wires, tank cars, and even for a tank steamer for carrying concentrated nitric acid in bulk.

Finishing Castings.—Simple castings may be polished by tumbling, finishing afterward on a buffing wheel. Quite rough castings are first polished with coarse emery, and then with fine emery on a canvas wheel, with grease and finally with No. 160 emery on a felt wheel. The final polish is given by buffing on a soft cotton wheel, using white polish.

Die Castings.—The Aluminum Castings Co. of Cleveland, Ohio, is the only plant in America manufacturing large aluminium die castings commercially.[1] The difficulties are its high melting point, its tendency to absorb iron, the relatively high shrinkage, and the weakness while solidifying. An alloy with 7 per cent. cadmium and a small amount of manganese has been used to remedy the shrinkage. The use of zinc is prevented because of the hot-shortness of the zinc-aluminium alloys. The castings are made almost entirely from 7 per cent. copper alloy, which can be easily prepared; it is strong while solidifying. The moulds are made of iron, constructed in sections. The mould is assembled and heated to a proper temperature, cooling pieces inserted where necessary, and the casting poured. Most of this assembling and taking apart of the mould is done mechanically. Castings thus made are of accurate size, have a very smooth surface and exceedingly close grain, and take a brilliant polish. Average tests of this alloy in sand castings and die castings are as follows:

	Sand Castings.	Die Castings.
Tensile strength	20,000 lb.	25,000 lb.
Elastic limit	13,000 lb.	13,000 lb.
Elongation in 2 in.	1.7 per cent.	3.1 per cent.
Specific gravity	2.84	2.87

[1] A. B. Norton, *Metal Industry*, December, 1914.

They are used in many types of electrical and scientific instruments, cash registers, slot machines, typewriters, adding machines, cooking utensils, automobile parts and aeroplane parts. Castings up to 30 lb. in weight are thus being made.

Moulding Flasks.—Foundry flasks are made of aluminium, with the exception of pins and ears which are of semi-steel, and catches and bolts which are all malleable iron and cold-rolled steel respectively. All the parts not aluminium are "Sherardized." The hinges contain bronze bushings and the top of the flask is protected by steel strips. The inside surfaces are grooved to hold sand. The flasks average 15 per cent. lighter than wooden flasks.[1]

Solders.—Aluminium solders[2] specially fitted to withstand the action of sea water are composed of:

	(1)	(2)
Aluminium	1.00	0.5
Phosphor tin (5 per cent. P)	0.50	0.25
Zinc	2.00	....
Tin	24.35	4.25
Lead	0.25	....

Wilkins and Morris[3] recommended a solder containing 5–5.5 parts of zinc and 8 parts of tin. M. and E. Richardson[4] make a solder of 58.6 Sn, 23.4 Zn and 17.6 Pb. C. F. Grim patents the solder: Zn 25, Sn 50, Pb 25. Cornande and DeCruys patent the solder: Zn 52, Al 17.5, Sn 30, Ni 0.5.

Alloys

Magnesium.—The German Reichsanstalt in Neubabelsberg[5] states that the high magnesium alloys can be duplicated by using zinc in low magnesium alloys. They recommend 2 to 6 per cent. of magnesium with 5 to 15 per cent. of zinc for zinc-magnesium alloys. By using copper also, the amount of magnesium can be still further reduced, as for instance, 0.25 to 0.5 Mg, 5 to 15 Zn and 5 Cu. The best "Duralumin" is said to be of this composition plus 0.5 to 0.8 per cent. of manganese. An alloy called "Mace" alloy consists of aluminium with 2 per cent. of magnesium and 5 to 10 per cent. of brass. L. M. Cohn[6] gives mechanical properties of the alloy with 0.39 per cent. Mg, 0.32 Cu and 9.40 Zn as: Tensile strength 32.3 kg. per sq. mm. (46,000 lb. per sq. in.) with 16.1 per cent. elongation; also of Duralumin containing 0.5 Mg as: Tensile

[1] *The Foundry*, **42**, 323 (1914).
[2] Baiky and Naraltum, Ltd. Eng. Patent 27835 of 1912, and 12972 of 1913.
[3] Eng. Patent 29239 of 1912.
[4] Eng. Patent 23077 of 1913.
[5] *Elektrochem. Zeits.*, **20**, 265 (1913).
[6] *Elektrochem. Zeits.*, **20**, 104 (1913).

strength 43.8 kg. (62,500 lb.) when heated to 400° C. and aged 8 to 10 hr., and 53 kg. (76,500 lb.) when cold worked afterward. Fendler and Stüber[1] state that Duralumin is not attacked by boiling in solution of 6 per cent. acetic acid and 2 per cent. sodium chloride, nor by this solution cold in 4 days.

Duralumin containing 0.5 Mg, 0.5 to 0.8 Mn and 3.5 to 5.5 Cu, tested in sheets 2 mm. (0.08 in.) thick, is reported as showing:

Tensile strength	47.5	kg. per sq. mm.	67,900 lb. per sq. in.
Elongation	4	per cent.	
Contraction of area	12	per cent.	
Hardness (Ball test)	139		
Modulus of elasticity	7000	kg.	10,000,000 lb.
Shearing strength	30	kg.	43,000 lb.
Specific gravity	2.79		

Krause describes the following alloys:

	Aluminium.	Magnesium.	Zinc.
Zimalium	93.45	3.75	2.8
Zimalium	88.49	7.07	4.43
Murmann alloys	92.0	3.6	4.4
Murmann alloys	72.0	13.5	14.5
Murmann alloys	76.9	11.5	11.6

Schirmester[2] determines the melting points as follows:

Mg, Per Cent.	Melting Points, ° C.	Mg, Per Cent.	Melting Point, ° C.
1	655	10	610
2	650	14	590
4	640	17	570
7	625	20	550

The alloys from 2 to 14 per cent. showed a halt in the cooling curve at 590° to 580° C. The alloys from 14 to 20 per cent. showed a halt in the cooling curve at 455°.

Silicon.[3]—Alloys were prepared by fusing aluminium and silicon together, adding cryolite as flux. The aluminium used contained Fe 0.51 and Si 0.2 per cent., melting point 654° C. The silicon used contained SiO_2 3.87 and Fe 0.32 per cent., melting point 1410° C.

The eutectic contains 10 per cent. silicon, melting at 580° C. The alloys showed the following melting points:

Silicon, Per Cent.	Melting Point, ° C.	Silicon, Per Cent.	Melting Point, ° C.
2.7	633	40.0	960
6.6	608	49.13	1035
7.2	603	63.7	1140
10.0	580	70.48	1230
18.25	695	73.5	1244
32.2	844	85.6	1335

[1] *Hygienische Rundschau*, 24, 59 (1914).
[2] *Metall und Erz*, p. 522, July 22, 1914.
[3] Chas. E. Roberts, *Jour. Chem. Soc.*, May, 1914.

The curve is that of a simple eutectic with no compounds. This agrees with the fact that no silicon hydride is evolved when the alloys are dissolved in acid. The conclusion is also confirmed by the microscopic study, agreeing with the previous study by Fraenkel.

Zinc.—To get the best results, 99.98 per cent. zinc should be used. The alloys up to 30 per cent. zinc consist of series of solid solutions which undergo no transformations while cooling. All castings should be annealed and rapid cooling and drawing or cold working should be avoided. The tensile strength increases to a maximum at 25 per cent. zinc, which latter has the best combination of strength with lightness, the specific gravity being 3.20 and strength 2 to 28 kg. per sq. mm. (35,000 to 40,000 lb. per sq. in.). In use they may be varnished, but salts of lead should be kept away from them.

Thos. A. Bayliss and B. G. Clark have patented two alloys consisting of:

	(1)	(2)
Aluminium	91	88
Zinc	8	10
Cadmium	1	2

They claim, in general, aluminium with zinc up to 20 per cent. and cadmium up to 10 per cent.

The aluminium is melted and the zinc and cadmium afterward added. It is stated to be strong and highly malleable. When cast in sand it has a smooth surface and can be readily machined.

A rather complex alloy, described as "stronger than aluminium bronze," is composed of 35 Al, 37 Zn, 14 Sb, 12 Sn, 1.20 Cu, 0.8 Pb.

Leddel recommends for use as bearing metal an alloy of 6.25 Al, 87.5 Zn, 6.25 Cu; another as 20.2 Al, 54.95 Zn, 22.7 Sn, 1.25 Pb, 0.55 Cu, 0.25 Fe.

Tin.—Lorenz and Plumeridge[1] studied the alloys of aluminium and tin and fix the eutectic at 2 atom per cent. of aluminium (Al_2Sn_{98}), equivalent to 0.47 per cent. aluminium. They found a complete absence of solid solutions.

Leddel states that 80 Al, 10 Sn, 10 Sb form a light alloy which can be used as a bearing metal.

Fletscher and Emperer recommend as bearing metal the one with 92.2 Al, 3 Cu, 1 Sn, 0.5 Sb; also one with 92.2 Al, 7.5 Cu, 0.25 Sn and 0.05 Fe.

For automobile castings, the alloy 87 Al, 8 Cu and 5 Sn is said to be preferable to the aluminium-zinc alloys. It would also be dearer.

[1] *Zeit. für anorg. Chem.*, **83**, 243 (1913).

Phosphorus.—Walter Ruebel alloys phosphorus with aluminium up to 15 per cent. With 4 to 7 per cent. of phosphorus the ductility and tensile strength are increased. With 7 to 15 per cent. of phosphorus the alloy becomes extremely hard and ductile and suitable for forging pieces of most various kinds. With 3 per cent. phosphorus it is suitable for horseshoes. With 2 per cent. it is rollable and suited for producing hard sheet and wire. With 1 per cent. the metal is excellently malleable and well suited for stamping, pressing and spinning. In all cases these alloys are easily soldered, very resistant to acids, and with high silver-white luster, which lasts well. The specific gravity is the same as that of pure aluminium. When cast into hot moulds and taken out of the moulds hot, in order that it may be cooled quickly, castings are obtained free from blow holes and cooling cracks.

Cobalt.—A. Neuburger[1] discusses the addition of 9 to 12 per cent. of cobalt to aluminium. The resulting alloys have a coarsely crystalline construction which is obviated by adding molybdenum or tungsten: Co 8 to 10 per cent., W 0.8 to 1.2; or Co 9 to 10 per cent., Mo 0.6 to 1 per cent. These alloys are said to have three times the tensile strength of pure aluminium; their malleability decreases as tungsten, molybdenum or cobalt are increased. The alloys containing tungsten are somewhat harder than those containing molybdenum.

Gold.—Haycock and Neville.[2] In dilute solutions of aluminium and gold, the diagrams show two series of solid solutions and a compound of Al_2Au_8, found in all alloys containing from 18 to 28 atom per cent. of aluminium. Evidence of a formation of the compound $AlAu_4$ was obtained.

Copper.—L. Guillet[3] examined the aluminium bronzes to which nickel had been added, and highly recommends that with 2.5 aluminium and 15 per cent. nickel.

Experiments are again being made by the U. S. Government, at the mint in Philadelphia, as to the suitability of aluminium bronze for one-cent pieces.

Hannemann and Merrica[4] discuss the metallographic characteristics of the aluminium-copper alloys, particularly those with 8 to 18 per cent. of aluminium. The strength of the bronzes hot has been investigated. The 2.4 per cent. bronze has only one-third its normal strength at 300° and one-eighth at 600° C. The 9.8 per cent. bronze increases in strength to 200° C., and above that gradually weakens.

Read and Graves[5] investigated alloys of copper, nickel and aluminium.

[1] *Elektrochem. Zeits.*, **20**, 295 (1914).
[2] *Phil. Trans.*, (A) **214**, 267 (1914).
[3] *Comptes rendus*, **158**, 704 (1914).
[4] *Zeits. f. Metallographie*, 1913, p. 209.
[5] *Jour. Inst. of Metals*, **11**, 169 (1914).

Analyses of aluminium: Si 0.17, Fe 0.18, Na 0.05. Alloys were made containing 1, 4 and 5 per cent. aluminium each with 1, 5, 10 and 15 per cent. nickel. The nickel makes the golden color of the alloys paler. Ten per cent. aluminium bronze in chill castings is strengthened by nickel up to 1 per cent. but at the expense of elongation and reduction of area. In annealed rods, 5 per cent. of nickel produces maximum improvement. In hard-rolled rods the strength is improved up to 7 per cent. nickel.

Five per cent. aluminium bronze in chill castings is greatly improved as regards elongation and reduction of area, up to 5 per cent. nickel. Above 5 per cent. nickel the strength is rapidly improved, while elongation and reduction of area decrease. The first 1 per cent. of nickel raises the elongation from 68 per cent. to 92 per cent.—a remarkable effect. In rods, 1 per cent. of nickel is similarly effective in increasing ductility, while the strength increases up to 7.5 per cent. nickel; there is no decrease of alternating stress strength until 1 per cent. of nickel is exceeded.

The hardness of 10 per cent. bronze is increased by 5 per cent. of nickel, while 5 per cent. bronze is unaffected up to 5 per cent. nickel and then increases rapidly in hardness.

The specific gravity of the 10 per cent. bronze is increased by adding nickel, but the 5 per cent. bronze is independent of the nickel content up to 15 per cent.

The melting points of the 10 per cent. bronze are unaffected by 5 per cent. nickel or less; the melting point of the 5 per cent. is increased by additions of nickel, commencing with 1 per cent.

The electrical conductivity of both 5 and 10 per cent. bronze rapidly decreases with the addition of nickel.

Nickel increases the rate of corrosion of the aluminium bronze when tested in soft water. In sea water, however, nickel up to 10 per cent. greatly reduces the corrosion, the effect of the first 1 per cent. of nickel on 10 per cent. bronze being very marked, reducing the amount of corrosion about three-fourths. In caustic solutions the rate of corrosion is slow and is diminished by the nickel, though not as greatly as in sea water. In vinegar, sulphuric acid and hydrochloric acid the presence of nickel increases the rate of corrosion.

Rübel Bronze corresponds to the formula Cu_2Fe_2NiAl, containing 38.9 per cent. Cu, 34.6 Fe, 18.2 Ni and 8.3 Al. It is said to have tensile strength of 83 kg. per sq. mm. (118,000 lb. per sq. in., with 3 per cent. elongation).

Rosenhain and Lansberg recommend the addition of 2 to 3 per cent. of manganese to aluminium bronze.

The Metall Works, Oberspree, produces an aluminium bronze containing nickel and iron, claimed to have a tensile strength of 110 kg. (157,000 lb. per sq. in.).

"Chromax Bronze," made by the Naulty Smelting and Refining Co., contains 66.66 per cent. Cu, 12.13 Zn, 15.16 Ni, 3.03 Cr and 3.03 Al. It has great hardness and resistance to chemical corrosion.

Miscellaneous.—W. A. McAdam patents the following new alloys:

(1)	Aluminium	100	This is said to be very strong and suitable for castings.
	Copper	18	
	Zinc	5	
	Antimony	3	
(2)	Aluminium	100	This is said to be strong casting alloy, particularly useful for surgical instruments.
	Silver	20	
	Zinc	10	
	Copper	5	
(3)	Aluminium	100	This is said to be soft alloy which can be easily rolled into foil.
	Cadmium	30	
	Tin	5	

"Ormiston Metal" is said to contain 97.5 per cent. aluminium, but no further information of its composition is given. Extravagant claims are made as to its physical properties.

"Albidur," manufactured by Otto Grison and Co., Magdeburg-Buckau, is of white color and is furnished in two qualities, soft and hard. The specific gravity of the soft is 2.9, the hard 3.0. The tensile strength of the softer alloy is about 18 kg. per sq. mm. (25,500 lb. per sq. in.), elongation 5 per cent.; harder alloy, 20 to 24 kg. (28,000 to 34,000 lb.), with 1 to 2 per cent. elongation.

"Weidrium," manufactured by Richard Weidener, Leipzig, Sellerhausen, has specific gravity between 2.75 and 3.1, tensile strength between 14 and 20 kg. (20,000 and 30,000 lb.), with 4 to 12 zinc or tin, and at times also magnesium or iron.

"Antherium," manufactured by Prett, Bowlie & Co., London, has specific gravity 2.4 to 2.57, tensile strength 29 kg. (42,000 lb.), elongation 17.5 per cent.

"Electrometall," manufactured by the Chemische Fabrik Griesheim-Electron, is an aluminium-magnesium alloy with specific gravity 1.8. It is evidently magnesium stiffened by a small percentage of aluminium.

Bauxite

By C. H. Gordon

The metal aluminium occurs in many different minerals, but from very few has its extraction up to the present been found practicable. Of these, bauxite, a hydrate of alumina, is the chief source of the metal. The composition of bauxite when pure is $Al_2O_3.2H_2O$, or Al_2O_3 73.9 per cent. and water 26.1 per cent. The name "gibbsite" is applied

to the crystalline variety having a higher content of water ($Al_2O_3.3H_2O$). The proportion of the metal aluminium in the above minerals is 39.13 per cent. and 34.6 per cent. respectively. Alumina occurs in the anhydrous form practically pure in the mineral corundum, but this substance is too valuable and occurs in insufficient quantity to be available as an ore of aluminium.

Prior to the discovery of bauxite, cryolite ($AlF_3.3NaF$), found in quantity in Greenland only, was the chief source of the metal.

As a mineral the alumina (Al_2O_3) in the ore may run as high as 70 per cent. or as low as 40 per cent. Other substances usually present are silica, iron oxide, and the oxide of titanium. The ore in a deposit always shows considerable variation in composition.

ANALYSES OF BAUXITE[1]

No.	Al_2O_3	Fe_2O_3	SiO_2	TiO_2	$CaCO_3$	H_2O	Moisture.
1	30.30	34.90	.....	.....	12.70	22.10	.....
2	55.40	24.80	4.80	3.20	0.20	11.60	.....
3	69.30	(a)22.90	0.30	3.40	.....	14.10	.....
4	76.90	0.10	2.20	4.00	.....	15.80	.....
5	61.89	1.96	6.01	.....	.....	27.82	.....
6	63.16	23.55	4.15	.....	.....	8.34	.....
7	62.05	1.66	2.00	.....	.....	30.31	3.50
8	87.30	1.43	6.40	3.99	.....	0.88	.....
9	62.46	0.81	4.72	0.23	.....	31.03	.....
10	57.58	0.96	9.38	2.76	.....	29.12	0.35
11	39.92	16.84	20.00	1.47	.....	19.52	1.25
12	61.00	2.20	2.10	.....	.....	31.58	3.12
13	49.90	4.13	(b)18.38	.....	.....	27.59	.....

(a) Includes both FeO and Fe_2O_3. (b) Insoluble.
1. Hard, compact, red bauxite, Baux, France. 2. d'Allauch, near Marseille, France. 3. Red bauxite from Theronet, Var, France. 4. White bauxite from Villeveyrac, Hérault, France. 5. Glenravel, Ireland. 6. Vochein, Germany. (Includes 0.79 per cent. of alkalies (Na_2O, K_2O). 7. Arkansas. 8. Washed calcined bauxite from Arkansas. 9, 10, 11. Wilkinson County, Georgia. 12. Rock Run, Alabama. 13. Keenburg, Tennessee.

Bauxite exhibits a variety of textures, the most common being a pisolitic or oolitic ore consisting of rounded, concretionary grains ranging in size from that of a pea up to 1 in. in diam., inclosed in a matrix of amorphous or clay-like ore. Another type found in certain deposits is the "granitic," which preserves in varying degree the granitic texture of the syenite from which the ore is derived.

The color of the ore varies greatly also, grading from light buff or white through gray to yellow, brown, or red, depending on the content of ferric iron. In hardness the ore may vary from that of a limestone to soft clay-like material that can be shoveled without picking. The upper portions of a deposit are usually harder as a result of the process of induration or cementing.

Bauxite melts at 1820° C. and bauxite clay at 1795° C.[2] Bricks made from the unrefined bauxite ore melt at 1740° C.

[1] MINERAL INDUSTRY, **22**, 47 (1913).
[2] MINERAL INDUSTRY, **21**, 94 (1912).

Deposits of bauxite occur in beds, or in pockets or lenses of variable diameter and depth in residual clays.

Bauxites and gibbsites belong to a class of rocks called laterites, which are the products of decomposition of alumina-bearing rocks and are characterized by the predominance of the hydroxides of alumina and iron with generally the oxide of titanium, and usually more or less silica. In a recently published memoir on the Laterites of French Guinea, Professor A. Lacroix[1] discusses at leng h the character and classification of this group of rocks. Gibbsite is defined as laterites containing $Al_2O_3.3H_2O$ in a crystalline state, and bauxite as laterite containing only colloidal hydrates.

In a review of Professor Lacroix's article, L. L. Fermor[2] gives Lacroix's classification slightly modified as follows:

CLASSIFICATION OF LATERITES

Divisions Based on Chemical Composition.	Subdivisions Based on Mineralogical Composition.
Laterites. (a) (L. C. ≷ 90 per cent.)	Gibbsites or gibbsitic laterites. Bauxites or bauxitic laterites.
Argillaceous laterites. (L. C. = 50 − 90 per cent.	Kaolin. (b) Lithomargic { Gibbsitic laterites and bauxitic laterites.
Kaolins. Lateritic clays. (L. C. < 50 per cent.)	Gibbsitic clays. Bauxitic clays.

(a) Lateritic constituents (L. C.) or hydrates, including also the anhydrous mineral hematite developed as a result of dehydration.
(b) Lithomargic is a term applied to the more or less impure and ferruginous variegated clays so often underlying the laterites of India.

As a result of leaching below and migration toward the surface, the iron tends to become concentrated close to the surface, and the hydroxide, by reason of its cementing property, forms a resistant crust. The phenomenon seems to be more pronounced in laterites formed from mica-schists than in those formed from diabases, gabbros, and syenites.

One of the characteristics of the crust is the absence of pisolitic forms. The formation of pisolites has long been regarded as taking place in waters in movement. While admitting the legitimacy of this opinion so far as it relates to the siliceous or calcareous pisolites of thermal springs, Lacroix regards it as inapplicable to pisolitic laterites. The pisolites of laterite are considered as having been formed *in situ* in a medium in a state of rest. They have not suffered transport since their formation, and their form, degree of regularity, and size depend on the physical state of the medium.

[1] Nouvelles Archives du Musee [V], 5, pp. 255–356.
[2] *Geol. Mag.* [VI], 11, 28–37, 77–82, 123–129; Jan., Feb., Mar., 1915.

PRODUCTION OF BAUXITE IN THE UNITED STATES BY STATES.
(In tons of 2240 lb.)

State.	1906	1906	1907 (a)	1908 (a)	1909 (a)	1910 (a)	1911 (a)	1912 (a)	1913 (a)	1914
Alabama.....	17,094	27,131	97,776	14,464	22,227	33,096	30,170	19,587	27,409	.....
Georgia.....								14,173		
Arkansas.....	30,897	51,200	(b)	(b)37,703	(b)106,814	(b)115,836	125,448	(b)126,105	(b)182,832	.....
Total.....	47,991	78,331	97,776	52,167	129,101	148,932	155,618	159,865	210,241	219,318

(a) Statistics of the U. S. Geol. Surv. (b) Production of Tennessee included.

CONSUMPTION OF BAUXITE IN THE UNITED STATES

Year.	Production.			Imports.		Consumption.	
	Long Tons.	Value.	Per Ton.	Long Tons.	Value.	Long Tons.	Value.
1905....	47,991	$203,960	4.25	11,726	$46,517	59,697	$250,477
1906....	78,331	352,490	(e)4.50	17,809	63,221	96,140	415,716
1907....	(a) 97,776	480,330	4.91	25,066	93,208	122,842	513,538
1908....	(a) 52,167	263,968	5.05	21,679	87,823	73,846	351,791
1909....	(a)129,101	679,447	5.27	18,689	83,956	147,789	163,403
1910....	149,679	778,203	5.33	15,720	65,743	164,601	782,001
1911....	155,618	750,649	4.87	43,222	164,301	198,840	914,950
1912....	160,124	900,620	5.00	26,214	95,431	186,079	864,363
1913....	210,241	997,698	4.75	21,456	85,746	231,697	1,083,444
1914....	219,318	1,069,194	4.87	24,844	96,500	244,162	1,165,694

(a) Statistics of the U. S. Geol. Surv. (e) Estimated.

WORLD'S PRODUCTION OF BAUXITE, 1910–1913, IN LONG TONS

Country.	1910		1911		1912		1913	
	Quantity.	Value.	Quantity.	Value.	Quantity.	Value.	Quantity.	Value.
United States.....	148,932	$716,258	155,617	$750,649	159,865	$768,932	210,241	$997,698
France.....	192,913	379,052	250,818	508,788	254,760	(a)	304,314	.....
United Kingdom..	3,792	4,292	6,007	6,297	5,790	6,881	8,282	.....
Italy.....	4,524	8,868	5,600	12,300	6,596	20,618	(b)5,880	.....
India.....	66	122	12	24	(a)	(a)	.....	.....
Total.....	350,227	$1,108,592	418,055	$1,278,058	.....	.....	.....	.....

(a) Statistics not available. (b) Alunite.

THE BAUXITE INDUSTRY BY STATES

Arkansas.—Arkansas easily takes the lead in the production of bauxite in America as a result of the mining operations of the American Bauxite Co., the leading producer of bauxite in this country. The major part of the production comes from the Bauxite district, about 18 miles southwest of Little Rock. The mines are located near the town of Bauxite on the Bauxite and Northern Railway, a spur of the St. Louis and Iron Mountain Railway, which crosses the tracks of the Chicago,

Rock Island and Pacific Railway at Bauxite station. Another less important district is the Fourche Mountain district, which lies immediately south of the city limits of Little Rock, in Pulaski County, about 14 miles northeast of the Bauxite district.

The major portion of the bauxite from this field is used for the production of metallic aluminium, though a considerable tonnage is used for the manufacture of the artificial abrasive, alundum, and some in the preparation of various salts of aluminium. Most of the ore for the production of metal is refined at East St. Louis, Ill., and reduced at Niagara Falls and Massena, N. Y., and Shawinigan Falls, Canada.

The bauxite occurs in beds having a maximum thickness of 30 to 35 ft., but locally the deposits wedge out as a result of erosion at the surface or a rise in the uneven surface of the syenite below. The average thickness of the commercial ore is about 11 ft.

Both pisolitic and granitic types are present, the former constituting the most common ore. A distinct gradation is noted from the pistolitic through granitic bauxite to the unaltered syenite upon which the deposits rest.

In his studies of these deposits Hayes,[1] following other observers, concluded that the bauxite was the result of water which gained access to the heated syenite intrusions and returning to the surface heavily charged with the constituents of the syenite in solution deposited them over the undulating surface of the syenite. This theory was regarded by Dr. Hayes himself as unsatisfactory and incomplete, but was presented as the best available at the time.

In a recently published paper on the Arkansas deposits W. J. Mead[2] gives the results of detailed studies involving much recent exploratory work. This author shows that the estimate of tonnage as given by Dr. Hayes is considerably in excess of the amount of bauxite actually present. Of special interest is the conclusion as to the origin of the ore. After describing in considerable detail the character and mode of occurrence of the deposits and giving conclusive evidence of the gradation, both chemical and mineralogical, from syenite through kaolinized syenite to bauxite, the author gives his conclusions as to the origin of the deposits as follows:

1. The bauxite and associated clays are the products of surface weathering of the syenite by normal processes of rock decomposition, and are in no sense chemical sediments. Bauxite deposits occurring on the syenite surface have developed *in situ* from the syenite. These show downward concentration of alumina. Bauxite lenses occurring inter-

[1] U. S. Geol. Surv., 21st Annual Report, Pt. III, pp. 441–472.
[2] Bauxite Deposits of Arkansas. *Econ. Geol.*, 10, 28–54 (1915).

stratified with the Tertiary sediments consist of material which has been removed from its place of origin by Tertiary streams.

2. The texture (granitic) of kaolinized syenite has been essential to the alteration of the kaolin to bauxite.

3. The oolitic or pisolitic texture of the bauxite has developed in place from the granitic or amorphous types of bauxite.

As stated, the chief producer of the Arkansas field is the American Bauxite Co., of Pittsburgh, Pa. The Republic Mining and Manufacturing Co., of Philadelphia, Pa., increased its tonnage somewhat over that of 1913. In addition to these the properties of the National Bauxite Co., of Philadelphia, Pa., were brought into operation and a heavy tonnage was mined and shipped.

California.—Bauxite exists in southern California but is not being mined.

Georgia and Alabama.—There are two areas in this region where bauxite is being mined—the Coosa Valley field and the central Georgia field.

The Coosa Valley field covers portions of Cherokee County in northeastern Alabama, and Bartow and Floyd Counties in northwestern Georgia. The district extends along the Coosa Valley from the vicinity of Summersville or Adamsville, Ga., to Jacksonville, Ala. The deposits occur in residual clay derived from the underlying dolomite or limestone and consist of rounded masses of ore several hundred feet in diameter at the surface and tapering downward.

The central Georgia deposits are located in Wilkinson County, about 30 miles west of Macon. They are near the margin of the coastal plain and about 150 miles south of the Coosa Valley deposits with which they have no connection, either grographical or geological. The bauxite here occurs in beds up to 10 ft. thick, resting upon the Tuscaloosa (Lower Cretaceous) clays at or near the contact with the overlying Claibourne (Tertiary) formations, or disseminated in nodules through the cretaceous clays. The ore, which varies in color from creamy white to bright red, is hard and generally pisolitic or concretionary, though in places it has a dense halloysitic, or even flinty, appearance.[1]

The principal producer in these areas is the Republic Mining & Manufacturing Co., which operates mines near Rock Run, Cherokee County, Ala., in Floyd County, and near McIntyre, Wilkinson County, Ga. The Cherokee Mining Co., of Linwood, Bartow County, Ga., operates some mines in Bartow and Floyd Counties, Ga.

The National Bauxite Co., of Philadelphia, Pa., has mines in Floyd County, Ga., but they were not worked in 1914.

[1] For analyses see: *Bull. Geol. Surv. of Ga.*, No. 18, pp. 430–437 (1909); *Min. Res. of the U. S.*, I, 929 (1909); MINERAL INDUSTRY, **21**, 89 (1912).

Tennessee.—The known deposits of bauxite in Tennessee occur in two localities in the Great Valley—on Sherman Heights on the east side of Missionary Ridge near Chattanooga, and near Keenburg, a station on the Virginia and Southwestern Railroad in Carter County.

The Chattanooga deposits occur in residual clays overlying the Knox dolomite, and lie near the fault line along which the dolomite has been overthrust upon the Chickamauga and Clinton formations lying to the northwest. The geological relations of the deposits here are similar to those of the Coosa Valley district.[1]

The only producer here is the National Bauxite Co., whose development operations undertaken in 1913 were continued and practically completed, and a fairly heavy tonnage shipped.

The Keenburg deposits occur about 200 miles northeast of Chattanooga, and in their structural relations are essentially like those of the Sherman Heights area. The Keenburg mine was opened by the National Bauxite Co. in June, 1912. In 1914 this company sold the property to the Watauga Mining Co., by whom operations were continued during the remainder of the year.

The production in Tennessee in 1914 was 6000 long tons, valued at $23,400.

Foreign Countries

France.—The deposits are found chiefly in southeastern France in the department of Languedoc-Provence (Herault, Bouches-du-Rhone, Var). They form a band extending almost parallel to the shore of the Mediterranean. The ore was disovered in 1822 by the chemist Berthier at Les Baux, northwest of Marseille, whence the name of the mineral. Bauxite has been found also in the eastern Pyrenees in the Ariege and in Auvergne.

In Provence and in the Languedoc the bauxite deposits are worked in open quarries and sometimes by underground mining, but it is rare that the depth is more than 50 meters from the surface. The exploitation of the Languedoc deposits was begun in 1873, but does not appear to have been carried on at first with great success. However, later, Mr. Auge discovered in the Saint-Porgoire at Villeveyrac (Herault) a heavy bed of white bauxite, and shortly after the Auge Co. was formed for the production of fire-bricks and alum. Afterward the increase in silicon content forced the Auge Co. to look for fresh deposits, and thus the fine bed of the Var was discovered, where the silicon does not often exceed 3 per cent. of the total. The rapid growth of the aluminium industry is causing increased production of bauxite.

[1] G. H. Ashley, Resources of Tennessee, December, 1911. Mineral Industry, 20, 95, 96 (1911).

Not much need be said of the bauxite deposit in the eastern Pyrenees. This discovery was made in the year 1906 by an engineer named Helson. He found the mineral in the Saint Antoine de Calamus chain of hills which extends parallel to the Rivesaltes-Quillain line, several kilometers distant from it. The deposits are found in the Queribus and the Calamus gorges on the southern slope of the chain. It would appear that erosion has removed the bauxite from the northern slope. These deposits are unfortunately found to be too rich in silicon to be of great industrial use. It is believed, however, that they might be utilized for the production of fire-bricks and perhaps also for alum, but they are not over-promising at present.

The following table of analysis of French bauxites has been prepared by Francis Laur:

	Water Content, Per Cent.	Silica, Per Cent.	Titanic Acid, Per Cent.	Iron Oxide, Per Cent.	Lime, Per Cent.	Aluminium, Per Cent.
VAR						
Red	12.90	1.75	21.38	3.21	.....	60.70
Rose	14.70	19.13	5.11	3.52	0.52	56.96
Lilac	15.09	8.11	3.07	2.85	.....	70.80
White	16.10	21.06	3.47	0.95	1.80	53.59
BOUCHES-DU-RHONE						
White	19.80	12.30	3.45	3.70	.....	60.20
Red	19.80	2.20	14.00	2.50	.....	61.30
HERAULT						
White	15.10	1.60	0.67	3.80	.....	78.53
Red	12.50	5.25	24.21	2.28	.....	55.51
Rose	15.60	5.95	5.09	2.39	.....	70.82
ARIEGE						
Rose	14.79	12.02	4.71	3.32	Traces	64.80

These figures are generally correct for average material. The iron oxide may sometimes make up 60 per cent. of the bauxite against only 0.5 per cent. at times, and the silicon also varies in similar degree. The one or the other may disappear altogether, but they are never both absent from the ore. There is a remarkable similarity between the bauxite deposits of the Var, and certain deposits of the region of Loupian (Herault) remarkably resemble deposits that have been observed in Algeria, at Rouma, and near Oran. It is therefore presumed that bauxite may have a similar origin to iron. Stanislas Meunier believes that bauxite is due to the action of chlorides resulting from the decomposition by heated

sea water of the ferruginous clays, but this hypothesis would not apply to the laterites. Like iron, bauxite occurs at various geological horizons.[1]

Germany.—Deposits of bauxite occur in Hesse and Nassau, but very little is mined.

Austria.—Bauxite of good quality occurs in the province of Istria in the form of pockets in red sandstone, but no production is reported from this district.

The mineral is also found at Carnigle and at Prichora in Styria. Deposits in Dalmatia have furnished a small amount for exportation to Germany.

Hungary.—Bauxite is found in southeastern Hungary near the boundary of Siebenbergen. Silica and titanic oxide occur mostly as quartz and titanium minerals. The specific gravity is 2.9 to 3.7. These deposits are described by Pauls,[2] who estimates the available tonnage as 20,000 tons.

Italy.—Bauxite has been found at several localities but there is only one producing mine. For the description of the deposits at Pescosolido in the Livi Valley, in the Terra di Lavoro district of Abruzzi, see MINERAL INDUSTRY, **20**, 96, 98 (1911).

India.—The extensive deposits of India remain practically undeveloped. Bauxite is said[3] to occur in Balaghat and Jubbelpore. The Katui quarries have produced small amounts, but no data are available for 1914.

United Kingdom.—Some bauxite is produced in Ireland from mines located at Stram in the County of Antrim, and the British Aluminium Co. works deposits at Glenravel. Deposits have been found also in Australia and New South Wales.

Africa.—Lacroix has described deposits of laterite in French Guinea,[4] some of which were notably gibbsitic and bauxitic, but the extent of the deposits is not given. Similar deposits occur also in Madagascar and in the province of Mozambique in Portuguese East Africa, south of Nyassaland, as described by Holmes.[5]

Dutch Guiana.—Extensive deposits of bauxite have recently been discovered on the Savamacca River in Dutch Guiana. Both red and white varieties occur, the former compact and of a granular texture, the latter in compact masses and very siliceous. The deposit occurs in the hills bordering the river, which offers favorable conditions for transportation by boats of light draft.[6]

[1] *Min. Sci. Press*, **108**, 734, May 2, 1914.
[2] *Zeits. für Praktische Geol.*, 1913; *Metal. and Eng.*, **22** (1914).
[3] J. A. Smith, *Daily Cons. and Tr. Rept.*
[4] Nouvelles Archives du Musee [V], **5**, 255–356 (1914). Reviewed by L. L. Fermor, in *Geol. Mag.* Jan., Feb., Mar., 1915.
[5] A. Holmes, *Geol. Mag.*, New Series [VI], **1**, 529–537, December, 1914.
[6] F. B. Percival, *Eng. Min. Jour.*, **99**, 583, Mar. 27, 1915.

Uses of Bauxite

Bauxite is at present used in the manufacture of aluminium, alums, bauxite brick, and a product called alundum, used in making artificial abrasives. (See Abrasives.) Most of that mined in Arkansas is used in the manufacture of aluminium, while most of that produced in Georgia, Alabama, and Tennessee is used in the manufacture of alums, such as the common alum of the drug store and that used by cities in the clarifying of water for domestic use.

When exposed to intense heat, bauxite which contains considerable iron oxide is converted into a solid mass of emery which is so hard that it can barely be cut by steel tools and resists chemical, thermal and mechanical action to a marked degree. The use of bauxite brick for the lining of rotary kilns, lead-refining furnaces, and basic open-hearth steel furnaces is growing.

For the manufacture of aluminium salts such as alum and aluminium sulphate the purer ores only are suitable.

The following table gives the domestic production, the imports, and the value of aluminium salts from 1909 to 1913, inclusive:

PRODUCTION AND IMPORTS OF ALUMINIUM SALTS[1]
(In short tons)

Years.	Production.						Imports. (a)	
	Alum.			Aluminum Sulphate.			Quantity.	Value.
	Quantity.	Value.	Per ton.	Quantity.	Value.	Per ton.		
1909.....	9,237	$295,682	$32.01	115,366	$2,214,122	$19.19	1,459	$29,061
1910.....	9,090	300,763	33.09	126,792	2,447,552	19.30	2,127	53,671
1911.....	10,468	329,686	31.49	134,077	2,743,336	20.46	2,283	56,833
1912.....	9,246	293,995	31.80	150,427	2,909,495	19.34	3,342	84,606
1913.....	9,605	312,822	32.57	157,749	2,977,708	18.88	2,702	66,549

[1] U. S. Geological Survey.
(a) Includes alumina, aluminium hydrate, or refined bauxite, alum, alum cake, aluminium sulphate, aluminous cake, and alum in crystals or ground.

A recent application of bauxite is in the manufacture of calcium aluminate to give a quick set to cement compositions.

By far the most important use of bauxite is for the production of the metal aluminium, the use of which is growing at a remarkable rate.

Alum

In addition to bauxite, various other alumina-bearing substances are used, as halloysite, alunite, alum shales, etc. The organization of the North America Chemical Co. for the purpose of manufacturing aluminium sulphate from halloysite found in northeast Georgia was mentioned

in MINERAL INDUSTRY, **26**, 55(1913). So also the alunite deposits of the United States and British Columbia have been regarded as possible sources of alum.

The mineral alunite, whose theoretical composition is $K_2O.Al_2O_3.4SO_3.6H_2O$ with alumina 27 per cent. and potash 11.4 per cent., has of late received considerable notice as a possible source of both alumina and potash. References to known deposits of alunite in the United States and South Australia will be found in MINERAL INDUSTRY, **22**, 53 (1913).

A deposit of alunite, the only one of the kind known in the northwestern part of North America, occurs at Kyoquot Sound, Vancouver Island.[1]

The deposits, which occur in a series of highly altered volcanics of Triassic or lower Jurassic age, were first located in 1908 and have been utilized to some extent by the British Columbia Pottery Co. as a fire clay, and by the San Juan Mining & Manufacturing Co. as a powdered cleanser. The alunite deposits which are owned by the last-named company have not been used, but the owners have announced their intention of manufacturing alum from them. Owing to the fact that the alunite is of the sodic variety, and to the further fact that it contains a large percentage of impurities, it is not considered very promising as a source of alum or other potash salts. Other deposits of alunite are found at Tolfa, Italy, in New South Wales at Bullah Delah, and in India. It is used directly for the manufacture of alum, both in Italy and in Australia.[2]

A plentiful deposit of alum rock occurs in the eastern part of the Turkish Vilayet (or province of Sivas), for a description of which see MINERAL INDUSTRY, **22**, 56, 57 (1911).

During 1914, investigations were continued under the direction of the Swedish government, started in 1913 for the purpose of determining the possibilities for the domestic production of aluminium sulphate, mineral oils, and sulphur from the alum shale or alum slate deposits found in large quantities in certain Swedish provinces.

Alum shales are mixtures of iron pyrites, aluminium silicate, and bituminous matter. Upon exposure to the weather the pyrites are oxidized to ferrous sulphate and sulphuric acid, which react to form aluminium sulphate (concentrated alum) and basic ferric sulphate.[3]

[1] C. H. Clapp, Alunite and Pyrophyllite in Triassic and Jurassic Volcanics at Kyoquot Sound, British Columbia. *Econ. Geol.*, **10**, 70–88, January, 1915.
[2] MINERAL INDUSTRY, **20**, 99 (1911).
[3] Emil Sauer, Consul, Goteborg, *Daily Cons. and Tr. Rept.*, June 19, 1914.

ANTIMONY

By Thomas Forrester Wettstein

Occurrence of Antimony

Antimony has been found native in mineral waters that contain iron, in coal and in river sands. Impurities are usually silver, iron and arsenic. It occurs in veins in Dauphiny, Bohemia; Sweden; the Harz; Mexico; and New Brunswick, Canada.

Principal Ores of Antimony

Antimony Glance, Sb_2S_3; also known as "Gray Antimony Ore," "Stibnite," "Antimonite." Antimony, 71.4 per cent.; sulphur, 28.6 per cent.

Native Antimony; too rare to be of commercial importance.

Valentinite, Sb_2O_3; rhombic; also known as "White Antimony" and "Antimony Bloom." Antimony, 83.4 per cent.; oxygen, 16.6 per cent.

Senarmontite, Sb_2O_3; cubic.

Kermesite, $2Sb_2S_3.Sb_2O_3$; also known as antimony oxysulphide, "Red Antimony Ore," "Antimony Blende," "Pyrostilbite."

Cervantite, Sb_2O_4; also known as "Antimony Ochre."

The following is a list of antimony minerals with their theoretical antimony contents:

	Per Cent.
Senarmontite	83.56
Valentinite	83.56
Cervantite	79.20
Kermesite	75.30
Stibnite	71.80
Volgerite	58.91
Guejarite	58.50
Berthierite	57.00
Livingstonite	53.12
Zinkenite	42.60

The antimony market is confined to a few smelters and speculating agents, and the price is a matter of private contract in most cases.

Antimonial lead ores carry from 3 to 10 per cent. antimony and are usually sold at the price of lead at the mine, and also sometimes by dealers on consideration that they receive the resulting hard lead at an advantage on the market price of lead.

The following are two analyses of refined antimony made by Pautrat:[1]

[1] *Revue de Chemie Industrielle*, March, 1907.

	Per Cent.	Per Cent.
Antimony	99.450	99.690
Sulphur	0.069	0.075
Iron	0.190	0.070
Lead	Trace	0.081
Arsenic	0.265	Trace
Sulphur dioxide	Trace	0.008
	99.974	99.924

"Crude Antimony" is a liquated sulphide of antimony. "Needle Antimony" is also a liquated sulphide of antimony. "Regulus Antimony" is the antimony of commerce; it may contain also sulphur and some impurities.

"Star Antimony" is the best brand and is guaranteed usually to contain at least 99.6 per cent. antimony.

Antimony During 1914

During the first half of 1914, the antimony market was in a dull and stagnant condition and there were practically no fluctuations. Cookson's averaged 7.25 cts. per lb. and Hallett's 6.95 cts.; ordinary grades averaged 5.87 cts.

These low prices were the result of the dullness and sluggishness of business in general. In July the ordinary grades declined still more, going as low as 5.25 cts., and as the supply kept up, notwithstanding the increasing demand, it was probable that it would touch as low as 5 cts.

August 1, however, brought the outbreak of the war and there was almost a panic among most consumers and speculators to buy. It will be remembered that during the Russo-Japanese war the price went as high as 26 cts., due to an increase in demand for ammunition. Speculators were right in their guess that this condition would be repeated and within 10 days the values trebled. The following is the scale of prices from July 31 to August 10, inclusive:

	Cookson's.	Ordinary.
July 31	7.200	5.500
Aug. 3	7.875	6.125
Aug. 4	8.250	6.625
Aug. 5	9.123	8.125
Aug. 6	13.000	11.000
Aug. 7	16.500	14.500
Aug. 10	20.500	17.500

Later in the month, after very severe fluctuations, the speculation seemed to decrease, and at the end of the month the ordinary grades were nominally 12.25 cts. per lb. At the time the market was very dull, since the acquisition of antimony for munition purposes was not immediate.

The September demand was practically nil, and the price declined to 8.50 cts. During September the Russian government started quietly to buy in England and Japan and early in October they began to draw on the American market. In the first week of October Russia bought 500 tons of spot antimony at from 8.50 to 11 cts., and another 350 tons at the end of the month at from 11 to 13 cts.

These total sales to Russia amounted to about 75 per cent. of the stock in New York. Since they could buy nothing further here, the

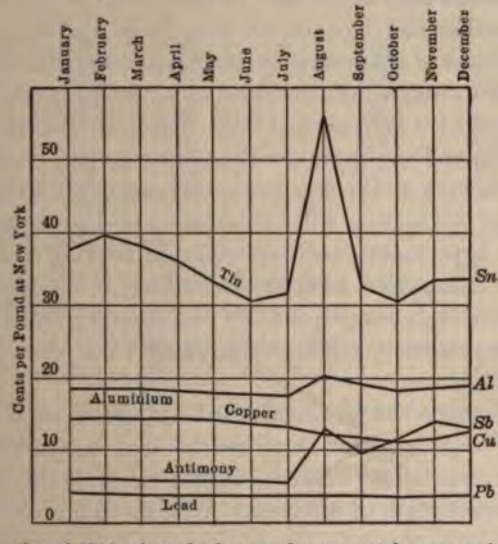

FIG. 1.—Fluctuation of 1914 prices of other non-ferrous metals compared with antimony.

reports showed that they had transferred their orders to Japan, which amounted to about 900 tons more, shipped direct to Vladivostock. About December 1, the Japanese government ordered 400 tons. This practically used up the entire supply, and this country could not get any offers from Japan for any quantity or for any delivery. At the end of the year spot and futures were alike, due to the advance in futures caused by the decrease in supply.

It has been estimated that since the war started Russia has bought 2500 tons and that a like amount has been purchased by other governments and armament makers, including the cartridge and shrapnel manufacturers in this country. England and France have placed embargoes on antimony and exports from these countries have not been allowed, except in a few special cases.

It is apparent at this time that this country will have to rely on Japan and China for their total supply, since it is likely that the embargo in

France and England will remain in effect until the end of the war, and nothing may be expected from Mexico as long as her internal troubles continue.

Antimony is ordinarily one of the cheaper metals, selling at one and one-half to two times the price of zinc; but after the outbreak of the European war it reached more than 20 cts. per lb., a price higher than that of aluminium, though it is now lower. As it has been pointed out in the U. S. Geological Survey report, at these prices antimony ores can not be worked profitably under the high labor cost prevailing in the mining regions in the United States unless the deposits are very large and advantageously situated. No deposits of antimony ore have been found in the United States which entirely fill these conditions, and as a result practically all the antimony metal used here is imported from European smelters, mostly from England. The ores from these smelters come largely from China, Mexico and France. So long as the war lasts, and especially so long as sea traffic is disturbed, the production will be curtailed and prices raised, for the use of antimony in type metal, and especially in bearing metals, is fixed and will continue. Other uses, such as the making of coffin trimmings, which consume a surprisingly large quantity of antimony and from which there is no secondary recovery, might conceivably turn to aluminium or other metals as substitute.

For several years the production of antimony in the United States from domestic ores has been confined to that contained in antimonial lead and small quantities recovered in the electrolytic refining of copper and lead. A production of antimony from foreign ores—which can only be estimated—is also made. The antimonial lead is mostly a by-product in the smelting of the precious metals, and efforts are made to save all possible so that this production can not be largely increased. The quantity saved in electrolytic copper refining can probably be increased, though not enough to make it a serious factor in the market.

It is probable that under the pressure of high prices attempts will be made, as in 1906–07, to work American deposits. If this can be done without great initial outlay, some antimony miners will probably make good profits; but it may be only a few months before prices will be back to or near those prevailing during the last 6 or 7 years.

A greater benefit than the temporary operation of the mines would probably accrue to this country from the establishment of smelters which would import and smelt Chinese, South American, Canadian and Mexican antimony ores. At present the only regular antimony smelting in this country is done by a smelter which is said to be a branch of an English smelter.

At one time the U. S. Metals Refining Company made very pure anti-

mony at its electrolytic lead refinery at Grasselli, Indiana, but the Company reports that none was made during 1914.

ANTIMONY STATISTICS OF THE UNITED STATES
(In tons of 2000 lb.)

Year.	Imports, Antimony Content.				Production. (a)		
					In Hard Lead.		
	Metals or Regulus.	In Ore.	Type Metal.	From Domestic Ore.	From Domestic Ore.	From Imported Ore.	Recovered from Old Alloys, Scrap, Dross, etc.
1904	2,028	1,245	630	486	2,571	.....	.....
1905	2,869	988	1,228	493	2,747	.....	.....
1906	3,950	1,124	1,853	404	1,362	.....	.....
1907	4,331	1,380	1,369	351	1,561	.....	.....
1908	4,057	1,640	422	.....	2,246	.....	.....
1909	4,826	1,693	1,327	.....	1,617	743	1,556
1910	4,950	*Nil.*	1,109	.....	1,598	631	2,779
1911	5,479	*Nil.*	727	.....	1,543	711	2,369
1912	6,969	*Nil.*	52	.....	1,224	725	2,506
1913	7,667	25	50	.....	2,204	304	2,705
1914	6,035	993	.....	.....	.....	.....	.....

(a) Figures of U. S. Geological Survey.

Although the production of antimony and antimonial lead is indirect, it is quite as important as a production of an equivalent quantity of segregated antimony, for there is a demand for antimonial lead which would have to be met by alloying the two metals were they not thus produced, and in fact most of the antimony imported both as metal and as ore is thus used.

The values given in the table of production are arbitrary and must not be taken as exact. Antimonial lead generally contains impurities, such as arsenic, iron and copper, and it is impracticable to obtain pure antimony and pure lead from the alloy at a cost low enough to afford a profit, though the alloy sells at a lower price than the metals singly. A rule by which antimonial lead is sometimes sold is to add the price of the contained antimony, supposing it to be equal to Cookson's, to that of the contained lead and then to subtract $5 per ton.

Imports.—A large quantity of antimonial lead is imported into the United States under the name of type metal, for which it is largely used. The table shows the imports of antimony in type metal. In custom's returns the lead content only is given, and it is assumed that the remainder is practically all antimony. This assumption is, however, wholly arbitrary, for imported type metal contains as much as 2 per cent. of impurities, such as iron, arsenic and copper, but there is no way of estimating its impurities. The antimony content, therefore, is probably too large by some quantity less than or approximately equal to 2 per cent. of the total quantity of type metal, and the correct percentage is correspondingly low.

The table shows also the imports of antimony and antimony ore for consumption, as obtained from the Bureau of Foreign and Domestic Commerce. Further details showing the values of these various materials are given in the tables of Imports and Exports at the end of this volume.

The following table shows the imports of antimony oxide for the fiscal year ending June 30:

IMPORTS OF ANTIMONY OXIDE

	Pounds.	Value.
1909	595,095	$65,596
1910	414,713	20,407
1911	942,616	50,371
1912	1,079,268	46,671
1913	1,819,323	97,447
1914 (a)	2,633,084	248,164

(a) Includes salt and compounds.

Prices.—Hallett's antimony generally sells for about 1 ct. per pound less than Cookson's, and other brands are lower according to quality and reputation, which seems to be fully as important.

AVERAGE MONTHLY PRICES OF ANTIMONY IN NEW YORK (a)
(Cents per lb.)

	Jan.	Feb.	Mar.	Apr.	May.	June.	July.	Aug.	Sept.	Oct.	Nov.	Dec.	Year.
1910.													
Cookson's	8.500	8.469	8.359	8.438	8.438	8.241	8.175	8.278	8.313	8.263	7.922	7.625	8.252
U. S.	7.988	7.969	7.938	7.938	7.938	7.938	7.938	7.938	7.938	7.900	7.656	7.438	7.876
Others	7.738	7.578	7.313	7.438	7.438	7.438	7.400	7.328	7.313	7.400	7.188	7.063	7.386
1911.													
Cookson's	8.25	8.38	9.56	9.54	9.50	8.75	8.50	8.44	8.31	8.14	7.97	7.78	8.59
U. S.	7.74	8.02	9.13	9.13	8.97			7.94	7.84	7.71	7.61	7.50	8.16
Others	7.5	7.65	9.00	8.52	7.99	7.42	7.35	7.36	7.26	6.96	6.92	6.82	7.54
1912.													
Cookson's	7.53	7.27	7.65	8.05	8.02	8.09	8.42	8.59	9.12	10.30	10.39	10.21	8.90
U. S.	7.47	7.44	7.56	7.75	7.75	7.78	7.96	7.98	8.50	9.62	9.86	9.62	8.26
Ordinaries	6.88	6.83	6.86	6.94	7.10	7.21	7.50	7.70	8.26	9.30	9.30	9.18	7.76
1913.													
Cookson's	9.94	9.47	9.28	9.13	8.88	8.79	8.54	8.38	8.37	7.60	7.62	7.50	8.73
U. S.	9.53	9.09	8.85	8.50	8.37	8.27	8.08	7.91	7.93	7.27	7.30	7.25	8 22
Ordinaries	8.97	8.25	8.18	7.98	7.79	7.64	7.55	7.39	7.37	6.49	6.45	13.9	7.52
1914.													
Cookson's	7.388	7.250	7.315	7.363	7.365	7.250	7.210	17.250	11.830	14.680	17.750	16.130	10.732
U. S	7.110	7.057	7.073	7.048	7.020	7.000	6.940	15.800	.....	.....	.....	.....	.....
Ordinaries	6.125	6.100	6.053	6.006	5.845	5.825	5.638	13.800	9.940	12.060	14.450	13.310	8.763

(a) From *Eng. Min. Jour.*

Consumption

Roughly, the consumption of antimony in the United States is indicated from the antimony produced from domestic and foreign ore, the secondary or recovered antimony, the antimony and antimonial lead, the imported antimony, the antimony contained in imported type metal, and the antimony contained in oxide. In 1910, the antimony consump-

tion amounted to 10,514 short tons; in 1911, to 10,502 short tons. The following is a detailed report of the domestic consumption of antimony in 1913 in short tons:

Material and Source.	Tons.	Value.
Antimony contained in antimonial lead from all sources, including by-product antimony	2,540	$430,491
Recovered from waste, scrap, etc. (including a little ore), nearly all as alloy	2,275	462,115
Imports:		
Metal and regulus	6,240	798,581
Crude antimony and ore (estimated antimony content)	1,200	137,780
Total approximate consumption of metallic antimony	12,755	1,828,967

The only figures obtainable for the consumption of antimony in 1914 show a decided increase in the consumption of crude antimony. This is due to the manufacturing in this country of antimony oxide from the crude antimony. Antimony oxide is lately being used to a very greatly increased extent for the vulcanization of rubber and for white enamels, such as are used in enameling bath-tubs and other sanitary articles.

PRODUCTION OF ANTIMONY METAL IN FOREIGN COUNTRIES
(In metric tons)

	1901.	1902.	1903.	1904.	1905.	1906.	1907.	1908.	1909.	1910.	1911.	1912.	1913.
Austria	114	24	14	36	90	*Nil.*	207	162	*Nil.*	*Nil.*	*Nil.*	13	.....
China(b)	.....	.....	.....	.....	3,353	3,829	2,316	9,356	7,937	6,643	6,986	13,531	13,032
France	1,786	1,725	2,748	2,116	2,396	3,433	3,945	3,850	5,444	4,640	4,775	5,406	6,390
Hungary(a)	706	683	732	1,007	756	1,322	841	670	695	782	892	859	1,038
Italy	1,721	1,574	905	836	327	537	610	345	59	*Nil.*	*Nil.*	*Nil.*	76
Japan	429	528	434	321	190	627	248	198	157	120	97	80	.....

(a) Regulus. (b) Exports of regulus and refined metal.

China (By T. T. Read).—The Hua Cheng Mining Co., of Changsha, Hunan, continues to be the principal producer, and has recently increased its scale of work so as to be by far the largest antimony producer in the world. This company has had a contract with the Chinese Eastern Antimony Co., a subsidiary of the Cookson interests, whereby the latter controlled the sale of the Hua Chang antimony. This contract proved so unfavorable to the mining company under war conditions that it has been abrogated, and the Hua Chang company in the autumn of 1914 established a sales agency of its own in New York and will hereafter sell direct to the trade. The war has greatly stimulated the production of antimony, as the product from the Changsha district for 1914 up to Nov. 1 is given as 11,830 metric tons. The smaller companies in Kuangtung province continue to operate on a small scale. A small production was

formerly maintained in Yunnan province, but stopped in 1912. Under the impulse of the higher prices prevailing work has been resumed and some 425 tons of regulus was produced during 1914. A Chinese company at Chih Tsun has done well, and is about to erect two more furnaces in addition to the four now in operation which produce about 2 tons of regulus per day.

Exports (By F. L. Cole): The exports from Hunan province, according to the returns of the Chinese Maritime Customs, were as follows:

PIKULS OF 133.33 POUNDS

Regulus	45,948
Crude	247,585
Ore	156,979
Ash	42,890

The ore was both oxide and sulphide. Ash was refuse from making crude antimony.

The exports from Yunnan province for the first three quarters of the year amounted to 5,624 pikuls, with an estimated export of 3000 pikuls for the last quarter.

Regulus is made at Mantze and Changsha by the volatilization process in Herrenschmidt furnaces. The oxid so obtained is smelted in small reverberatory furnaces and a high-grade metal is obtained. In Changsha the Wah Chang Mining and Smelting Co. also make regulus from oxid ores in reverberatory furnaces and from high grade ores and crude by a slow roasting process, followed by smelting the resulting oxid in reverberatory furnaces. The capacity of the Wah Chang company's plant is 12 tons per day, and is being increased. The high prices for all kinds of antimony products have stimulated the industry in Hunan and the output is being generally increased.

ARSENIC

By Kenneth H. Read

The arsenic market in 1914 was marked by no great changes or important occurrences, save an increase in the production over the past year. The American production acted as a balance wheel to the trade, increasing the demand and keeping the price down to a standard which varied but little. The war, contrary to all predictions, had no noticeable effect on the market in this country. There was of course some trouble regarding shipments, but not sufficient to exert much influence over the prices, so that what could be said of the market 6 months or a year ago is equally true to-day.

The sources of supply are about the same as last year. The political disquietude in Mexico continued to interfere with shipments from that quarter, but Canada contributed its usual quota, the decrease in some localities being balanced by increase in others. The Canadian production is chiefly as a by-product in the reduction of cobalt-silver arsenides from northern Ontario, two firms in the province being engaged in this business. The auriferous arsenopyrite bodies are so plentiful in eastern Ontario, Nova Scotia, and Cape Breton as to form an important source of supply.

According to the final figures collected by F. L. Hess of the U. S. Geological Survey, arsenious oxide was produced in the United States in 1914 only as a by-product of the smelting of lead, silver, copper, and gold. The output was, however, the largest made in this country, amounting to 4670 short tons, valued at $313,147, being an increase of more than two-thirds over the output of the previous year and over one-third greater than the largest previous annual output.

STATISTICS OF WHITE ARSENIC IN THE UNITED STATES

Year.	Production.			Imports.			Total.	
	Pounds.	Value.	Per lb.	Pounds.	Value.	Per lb.	Pounds.	Value.
1900	.....	.....	.....	5,765,559	265,500	0.04¾	5,765,559	265,500
1901	600,000	$18,000	$0.03	6,989,668	316,525	0.04½	7,589,668	334,525
1902	2,706,000	81,180	0.03	6,110,898	280,055	0.04½	8,816,898	361,235
1903	1,222,000	36,691	0.03	7,146,362	256,097	0.03½	8,368,362	292,788
1904	996,456	29,504	0.03	6,391,566	226,481	0.03½	7,388,022	255,985
1905	1,545,400	50,225	0.03¼	6,444,083	219,198	0.03½	7,989,483	269,423
1906	1,663,000	83,150	0.05	7,639,507	336,609	0.04½	9,302,507	419,759
1907	2,020,000	101,000	0.05	9,922,870	553,440	0.05½	11,942,870	654,440
1908	2,603,505	99,193	0.03¾	9,592,881	417,137	0.04⅜	12,196,386	516,330
1909	2,015,880	57,957	0.02⅞	7,183,644	272,493	0.03¾	9,199,524	330,450
1910	2,652,000	66,300	0.02½	8,204,123	250,115	0.03	10,856,123	316,415
1911	6,162,000	123,240	0.02	6,916,069	203,766	0.02⅞	13,078,069	327,006
1912	6,282,000	190,757	0.035	6,205,562	200,616	0.03¼	12,487,562	391,373
1913	4,750,000	142,340	0.03	5,164,768	223,525	0.04⅓	9,914,768	365,865
1914	9,340,000	313,147	0.034	3,188,368	110,121	0.035	12,528,368	361,389

There has been no direct production of arsenic from its minerals in the United States for a number of years. This is due entirely to the fact that its by-product production and enforced collection is so large as to keep the price down below a figure which would make the direct production profitable. Works for this purpose have been erected at only two places in the United States—Brinton, Va., and Mineral, Wash. These plants can produce arsenic to be sold in competition with the by-product during periods of high prices only, such as may prevail if the present war and its attendant industrial disturbances be long continued.

The melting point of metallic arsenic, though generally stated to be 500° C. when heated under pressure sufficient to prevent its sublimation, has been recently determined by W. Heike of Freiburg, by use of a special receptacle, to be 830° C., no thermal effects being noted below its melting point.

An installation of the Cottrell process has been made in the Arizona plant of the Anaconda Copper Co., at Anaconda, Mont., for the purpose of removing the arsenic from the flue dust. The plan was to roast the flue dust to remove the arsenic from the other metal values, separating the mechanically carried impurities from the gases at high temperature, and then cool the gases sufficiently to condense the pure arsenic and recover it directly, without the necessity of a second refining. Further details of this installation will be found in the special chapter on "The Smoke Problem in the Mineral Industries" at the end of this volume.

WORLD'S PRODUCTION OF ARSENIC
(In metric tons)

Year.	Canada. (a)	Germany. (b)	Italy. (d)	Japan. (a)	Portugal. (d)	Spain. (b)	United Kingdom. (a)	United States. (a)	France. (d)
1899	52	2,423	304	5	1,083	101	3,890	.....	2,600
1900	275	2,414	120	5	1,031	150	4,146	.....	4,705
1901	630	2,549	.....	10	527	120	3,416	272	7,491
1902	726	2,828	.....	12	736	71	2,165	1,226	5,372
1903	233	2,768	50	6	698	1,088	916	554	6,658
1904	66	2,829	80	4	1,370	400	992	452	3,117
1905	*Nil.*	2,535	.....	8	1,562	1,140	1,552	701	3,627
1906	*Nil.*	3,052	.....	5	1,322	1,114	1,625	754	6,534
1907	317	2,904	73	7	1,538	2,400	1,523	916	7,900
1908	649	2,822	451	20	1,655	2,004	2,007	1,301	2,381
1909	1,020	2,911	*Nil.*	8	1,420	506	2,911	914	2,141
1910	1,363	3,066	*Nil.*	12	974	444	2,187	1,203	8,045
1911	1,815	2,981	16	6	887	331	2,178	2,800	19,000
1912	1,858	4,869	*Nil.*	.....	1,006	(c)	2,228	2,855	81,880
1913	1,538	.....	.....	.....	925	.....	1,716	2,158	70,613
1914	1,576	.....	.....	.....	.....	.....	1,722	4,238	.....

(a) White arsenic. (b) Oxide, sulphide, etc. (c) Not yet available. (d) Ore.

ASBESTOS

By Oliver B. Hopkins

The recovery of the asbestos industry in 1913 from the depression of the previous year, and its further expansion, continued for the first half of 1914; during the latter half of that year, however, there was a marked falling off in the production and an increase in the supply of raw material on hand, due to the disturbed condition brought about by the European war. Had normal conditions continued, the reports for the year would have shown the greatest production in the history of the asbestos industry.

The United States never has been an important factor in the world's production of asbestos, although more is manufactured here than in any other country. According to Diller,[1] "the nearness and reliability of the Canadian supply, largely owned in the United States, evidently constitute the basis for the American supremacy in the development of asbestos manufactures." As the following table will show, the world's production of asbestos is drawn largely from Quebec, Canada:

WORLD'S PRODUCTION OF ASBESTOS, 1907-1913
(In short tons)

Country.	1907.	1908.	1909.	1910.	1911.	1912.	1913.
United States	653	936	3,085	3,693	7,604	4,403	1,100
Africa:							
Cape Colony	604	1,267	1,674	1,403	1,253	1,217	(b)
Natal	.....	.....	.....	3	13	3	(b)
Rhodesia	.....	55	272	332	460	(c) 1,234	(b)
Transvaal	.....	.....	.....	77	.....	.....	(b)
Australia	.....	45	3	.....	.....	.....	(b)
Canada:							
Asbestos	62,130	66,548	63,349	77,508	(d) 101,393	(d) 111,561	136,951
Asbestic	28,296	24,225	23,951	24,707	(d) 26,021	(d) 24,740	24,135
Cyprus	99	521	172	487	799	860	(b)
India	.....	.....	.....	3	.....	.....	(b)
Italy	(e) 396	396	210	193	184	186	169
Russia	11,497	13,129	(f) 14,654	12,055	17,124	(f) 18,138	18,594

(a) Statistics compiled by U. S. Geological Survey, from Mines and Quarries: General Report with Statistics, pt. 4, London, up to 1912.
(b) Statistics not available.
(c) The Mineral Industry, 1912, New York.
(d) Report on the mineral production of Canada, calendar year 1912, Ottawa.
(e) From the *Ministerio delle Finanze*, Rome.
(f) *Min. Jour.*, London.

Each year brings new uses and new demands for asbestos and consequently an ever-increasing market. The demand for asbestos for build-

[1] *Min. Res. of U. S.*, 1912.

ing purposes, such as shingles, asbestos lumber and sheathing, will doubtless increase year by year as lumber becomes more scarce and more expensive; furthermore, its use as a heat-resisting and especially as an insulating material will necessarily increase and, so far as is known, it can not be satisfactorily replaced by any substitute. Asbestos-cement sheets are being extensively employed as a fire-proof and moisture-proof material in the construction of sanatoria, barracks, schools, motion-picture houses, etc. In brief, asbestos, together with cement, would seem to be destined to take a most important place as a future building material for many reasons, principally because of its adaptability and cheapness.

UNITED STATES

Notwithstanding the fact that asbestos is known in the United States in a large number of widely separated localities, the production has been small and variable. Georgia is the only state in which asbestos mining has been carried on systematically or for any length of time; the Sall Mountain company, with its mill at Gainesville, Georgia, has been active for more than 20 years. There are two types of asbestos found in this country in deposits of commercial size—amphibole asbestos in the form of dikes or irregular-shaped masses, and chrysotile, or serpentine asbestos, as cross-fiber veins in serpentine. The deposits of Georgia and Idaho are of the former type; those of Vermont, Wyoming, California, and Arizona are of the latter type.

The statistics for the production and imports of asbestos in the United States, so far as they are available at the present time, are given in the following tables:

ASBESTOS STATISTICS OF THE UNITED STATES (a)

Year.	Production.			Imports.		
	Short Tons.	Value.	Value per Ton.	Manufactured.	Unmanufactured.	Total.
1900	1,100	$16,500	$15.00	$24,155	$331,796	$355,951
1901	747	13,498	18.08	24,741	667,087	691,828
1902	1,010	12,400	12.27	33,313	729,421	762,734
1903	887	16,760	18.90	32,058	657,269	689,327
1904	1,480	25,740	17.40	51,290	700,572	751,862
1905	3,100	126,300	40.74	70,117	776,362	846,479
1906	1,695	28,565	16.85	96,162	1,010,453	1,106,615
1907	950	11,700	12.32	200,371	1,104,110	1,304,481
1908	1,350	24,000	17.78	147,548	1,068,342	1,215,890
1909	4,025	87,625	21.77	240,381	993,254	1,233,635
1910	3,630	64,350	18.80	308,078	1,235,170	1,543,248
1911	7,604	119,935	15.77	290,098	1,413,541	1,703,639
1912	4,403	87,959	19.97	363,759	1,456,012	1,819,771
1913	1,100	11,000	10.00	389,664	1,928,705	2,318,369
1914	1,247	16,810	13.48	368,344	1,407,758	1,776,102

(a) *Min. Resources U. S.*, 1913, U. S. Geol. Survey, chapter on Asbestos.
(b) Statistics not available.

GENERAL IMPORTS OF ASBESTOS INTO THE UNITED STATES, CALENDAR YEARS 1913 AND 1914 (a)
(In short tons)

Country.	1913.			1914.		
	Unmanufactured.		Manufactures of.	Unmanufactured.		Manufactures of.
	Quantity.	Value.	Value.	Quantity.	Value.	Value.
Austria-Hungary	.....	.....	$75,770	.....	.....	$47,982
Belgium	.....	.....	28,616	.....	.....	20,267
Canada	86,564	$1,897,611	7,456	71,781	$1,393,732	19,007
Denmark	.....	.....	.....	.....	.....	4,984
England	1	1,546	176,413	.....	.....	159,098
France	.....	.....	4,202	.....	.....	2,863
Germany	17	3,547	88,526	11	2,209	104,368
Italy	5	694	6,937	2	631	8,020
Japan	.....	.....	215	.....	.....	.....
Netherlands	.....	.....	.....	.....	.....	236
Russia in Europe	150	25,307	.....	72	11,186	.....
Scotland	.....	.....	1,489	.....	.....	1,389
Switzerland	.....	.....	40	.....	.....	.....
Mexico	.....	.....	.....	.....	.....	130
Total	86,737	$1,928,705	$389,664	71,866	$1,407,758	$368,344

(a) Statistics of the U. S. Geological Survey.

The value of the manufactured and unmanufactured asbestos imported for consumption into the United States during the calendar years 1909 to 1914 is shown in the following table:

ASBESTOS IMPORTED FOR CONSUMPTION INTO THE UNITED STATES, 1909-1914 (a)

Year.	Unmanufactured.	Manufactured.	Total.
1909	$993,254	$240,381	$1,233,635
1910	1,235,170	308,078	1,543,248
1911	1,413,541	290,098	1,703,639
1912	1,456,012	363,759	1,819,771
1913	1,928,705	378,961	2,307,666
1914	1,407,754	371,469	1,779,223

(a) Statistics of the U. S. Geological Survey.

Arizona.[1]—The asbestos deposits of Arizona are characterized by the high grade of the fiber and the unusual modes of occurrence. Asbestos has been known for a long time in the Grand Canyon near the town by that name and has been described by Pratt and Noble[2]; more lately, however, deposits have been discovered near Globe on Ash Creek under the same geological conditions as those farther north.

The fiber from both places is extraordinarily pure and contains less than one-fourth as much iron as the material from Canada, thus making it particularly desirable for certain purposes. It occurs as veins in ser-

[1] J. S. Diller, *Min. Res. of U. S.*, pp. 342-347 (1913).
[2] J. R. Pratt, *Min. Res. of U. S.*, pp. 1137-1140 (1914). L. F. Noble, *Am. Jour. Sci.* [4], **29**, 520-522 (1910).

pentine which is derived from limestone through the influence of intruded diabase with which it is associated. The asbestos here is thus derived from sedimentary rocks rather than igneous rocks, as is the case with the most important deposits of the world.

Considerable prospecting has been done near Globe, the most accessible deposits of the state, and the material has been tested with promising results. If transportation difficulties can be satisfactorily solved, this will probably become an important producing area of high-grade asbestos.

California.—Deposits of asbestos are known in eight counties in California; in four of them mining has been started at different times in a small way, and in the others there has been some prospecting.

During the past year there has been considerable interest taken in these deposits; on the east fork of Trinity River, 18 miles east of Carrville, a mill is said to have been installed and an effort made to build a road to Castella, the nearest railroad point on the Southern Pacific. With proper transportation facilities it is claimed that it will be profitable to work these deposits.

Georgia.[1]—Until a short time ago the asbestos industry in Georgia has been more active than usual. During the past year there have been three producing companies developing deposits in White and Habersham Counties. As a considerable percentage of the production has been shipped abroad, the present condition of the foreign market has caused the companies either to shut down entirely or to reduce their production.

The asbestos found in Georgia is of the amphibole variety and occurs as either mass-, slip-, or cross-fiber. The valuable deposits occur as dikes or irregular-shaped bodies of mass-fiber in which from 90 to 95 per cent. of the material mined is realized as fiber. The fiber is short and of a low grade, but well suited for making cement, shingles, wall plaster, etc. Two of the producing companies in Georgia have been making cement by adding a small percentage of medium-grade chrysotile asbestos and a fixed percentage of white plastic clay, which can be obtained in Georgia at a very reasonable price. The local demand for asbestos cement has thus been satisfied largely by local products.

Idaho.—Asbestos of the mass-fiber amphibole type occurs in large quantities at Glenwood, 12 miles from Kamiah, Idaho. In regard to this deposit: "Statement is made that the building will be completed and the machinery installed for the manufacture of asbestos shingles within 6 or 7 weeks. It is said that asbestos roofing can be made and sold here at but little more than the cost of cedar shingles, that it is fireproof and is impervious to water."[2]

[1] For description of Georgia deposits see: *Bull.* 29, Geol. Survey, Georgia; *Bull. Am. Inst. Min. Eng.*, pp. 2275–2284, Sept., 1914.
[2] *Min. Eng. World*, p. 478, March 6, 1915.

Vermont.—The southern continuation of the serpentine area of Quebec, with its associated deposits of asbestos, has been developed to a limited extent on Mount Belvedere, Vermont, by the Lowell Lumber and Asbestos Co. The deposits were worked at this locality from 1907 until 1911, when the mill was closed because of labor, transportation, and other troubles. Since then the property has lain idle, but it is expected to be opened up as soon as market conditions seem to justify it.

Wyoming.—The deposits of asbestos near Casper, Wyoming, have been prospected to a limited extent for some years past, but no systematic mining has been carried on. A consolidation of five asbestos companies under the name of Mid-West Asbestos Co. was effected in 1914 and extensive plans have been made to develop the property. The area covered by the asbestos-bearing rock is known to be large; and, although the material is said to be of low grade, its value will depend on the percentage of fiber that can be obtained and the cost of extraction, since the demand is increasing, particularly for low-grade fiber.

Foreign Countries

Australia.—No production has been reported from Australia since 1909, when there was an export of 3 tons from Soanesville, in Pilbarra district, West Australia. Asbestos of the crocidolite variety, or blue asbestos, occurs at two localities in South Australia, 19 miles from Hawker, and 23 miles northeast of Eudunda. During 1912 a few hundred pounds was quarried for experimental work; in 1913 there was no production.

Canada.—Since 1900, when the world's production of asbestos was less than one-fourth what it is at present, Canada has produced annually from 80 to 90 per cent. of the world's supply. The fact that Canada has established and maintained her supremacy in the production of asbestos is especially significant, considering the wide distribution of serpentine rocks under conditions similar to those which have given rise to the commercial deposits in that country. The deposits are associated with altered, basic, igneous rocks which occur as intrusive dikes or sills in early Paleozoic or pre-Paleozoic rocks, which are exposed at intervals from Newfoundland to Alabama. It is also interesting to note that the Canadian production is derived largely from eight mines, seven of which are within a distance of 6 miles.[1] In general, the rocks which alter to serpentine with the formation of more or less chrysotile, or serpentine asbestos, in Canada and the northeastern part of the United States, alter

[1] J. A. Dresser, *Can. Min. Jour.*, p. 600, Sept. 15, 1914.

dominantly to amphibole with a variable development of amphibole asbestos in the southern part of the Appalachians, a fact which may be due to greater metamorphism to the south consequent to more extensive deformation.

The Canadian production in 1914 was obtained from the districts of Black Lake, Thetford, Robertsville, and Danville in the Province of Quebec. The total output[1] for the year was 107,668 tons, as compared with 132,564 tons during 1913, a decrease of 24,896 tons, or 18.7 per cent. The total quantity of asbestos rock milled during the year is reported as 1,717,629 tons, with an estimated average content of about 6.03 per cent. of fiber. The sales and shipments of asbestos during 1914 were 96,542 tons, valued at $2,892,266, or an average of $29.96 per ton, as compared with sales in 1913 of 136,951 tons, valued at $3,830,909, or an average of $27.97 per ton.

The number of men employed in the mines, quarries, and mills, was 2,992, and the amount paid in wages was $1,283,977; during 1913 there were 2,951 men employed and $1,687,957 was paid in wages.

In the following table, which shows the output, sales, and stocks in 1914, the classification is based on valuation: Crude No. 1 includes material valued at $200 per ton and upward, and Crude No. 2 less than $200; mill stock No. 1 includes mill fiber valued at $30 and upward, No. 2 from $15 to $30, and No. 3 under $15 per ton.

OUTPUT, SALES AND STOCKS IN 1914 (a)
(Subject to Correction)

	Output.	Sales.			Stock on hand, Dec. 31.		
	Tons.	Tons.	Value.	Per ton.	Tons.	Value.	Per ton.
Crude No. 1	1,450.55	1,335.9	$402,417	$301.23	984.3	$301,237	$306.04
Crude No. 2	2,610.4	2,811.65	370,776	131.87	1,410.9	187,338	132.78
Mill stock No. 1	16,144	19,388	932,893	48.12	4,616	229,361	49.69
Mill stock No. 2	58,362	47,851	963,973	20.15	15,114	305,809	20.23
Mill stock No. 3	29,101	25,155	222,207	8.83	9,046	76,522	8.46
Asbestos	107,667.95	96,541.55	$2,892,266	$29.96	31,171.2	$1,100,267	$35.30
Asbestic	.....	21,031	17,540	0.83	.....	.....	.....

(a) John McLeish, Preliminary Report on the Mineral Production of Canada for 1914.

Exports of asbestos during the calendar year 1914 were 81,081 tons, valued at $2,298,646, as against 103,812 tons, valued at $2,848,047, in 1913. There was also an export classed as asbestos sand in 1914, amounting to 18,991 tons, valued at $108,548, or an average of $5.71 per ton.

[1] Preliminary Report on the Mineral Production of Canada During the Calendar Year, 1914. Dept. of Mines, Canada.

SALES OF ASBESTOS AND ASBESTIC IN CANADA FOR THE CALENDAR YEARS 1895–1914, IN SHORT TONS (a)

Year.	Asbestos.		Asbestic.		Total.	
	Quantity.	Value.	Quantity.	Value.	Quantity.	Value.
1895	8,756	$368,175	.....	.....	8,756	$368,175
1896	10,892	423,066	1,358	$6,790	12,250	429,856
1897	13,202	399,528	17,240	45,840	30,442	445,368
1898	16,124	475,131	7,661	16,066	23,785	491,197
1899	17,700	468,635	7,746	17,214	25,446	485,849
1900	21,621	729,886	7,520	18,545	29,141	748,431
1901	32,892	1,248,645	7,325	11,114	40,217	1,259,759
1902	30,219	1,126,688	10,197	21,631	40,416	1,148,819
1903	31,129	915,888	10,548	16,869	41,677	932,757
1904	35,611	1,213,502	12,854	12,850	48,465	1,226,352
1905	50,669	1,486,359	17,594	16,900	68,263	1,503,259
1906	60,761	2,036,428	21,424	23,715	82,185	2,060,143
1907	62,130	2,484,768	28,296	20,275	90,426	2,505,043
1908	66,548	2,555,361	24,225	17,974	90,773	2,573,335
1909	63,349	2,284,587	23,951	17,188	87,300	2,301,775
1910	77,508	2,555,974	24,707	17,629	102,215	2,573,603
1911	101,393	2,922,062	26,021	21,046	127,414	2,943,108
1912	106,520	2,959,677	24,740	19,707	131,260	2,979,384
1913	136,951.3	3,830,909	24,135	19,016	161,086.3	3,848,925
1914	96,541.55	2,892,266	21,031	17,540	117,572.55	2,909,806

(a) Obtained from the report of the Director of Mines on the mines and metallurgical industries of Canada for 1907–08, pp. 448, 936. The data for 1909, 1910, 1911, 1912, 1913 and 1914 were obtained from the general summary of the mineral production of Canada.

In addition to the deposits in the eastern part of Canada, asbestos has been found in British Columbia[1] in Tulameen district. Here it occurs in almost pure olivine rocks which have been altered to a variable extent to serpentine, as in the eastern provinces. The veins vary in width from one-fourth of an inch to mere threads. No prospecting has been done in connection with these deposits.

Cyprus.—The latest statistics regarding the asbestos industry in Cyprus relate to 1912, when 860 tons was produced. It was reported for the year that the industry was making steady progress, notwithstanding labor and transportation difficulties.

Italy.—The latest statistics available for Italy show a production of 193 tons in 1913, a quantity slightly in excess of what it was in the two previous years. For some decades Italy has produced asbestos in small quantities.

Russia.—The statistics for 1914 for the production of asbestos in Russia are not yet available. The production for 1913 amounted to 18,594 tons, which is slightly in excess of what it was for 1912. While the production of asbestos in Russia has not increased as fast as it has in Canada, the industry is well established and each year there is an increase in the amount produced.

South Africa.—Asbestos has been quarried in a desultory manner in the following countries: Cape Colony, Rhodesia, Natal, and Transvaal.

During 1914 considerable interest was taken in the deposits of the

[1] *Memoir* 26, Dept. of Mines, Canada, pp. 171–172.

Carolina area of the Transvaal, where mining operations were suspended some years previous as being unprofitable. Certain British asbestos merchants have made an agreement to work the deposits on a tributing basis, paying the laborers for the asbestos they win and leaving the method of mining to the choice of the individual.

No statistics are available for Natal since 1912, when 3 tons of asbestos was produced.

A new and important discovery of asbestos was announced in May, 1914,[1] as having been made in Mashata district of Rhodesia, 25 miles west of Victoria township. The fiber is reported to be of high grade and easily separated from the matrix; the minimum production per native is reported to be 100 pounds, the percentage of fiber varying from 6 to 10 per cent. The King Asbestos Co., Ltd., reported in June, 1914, that the deepest part of their mine in the new district had reached 42 ft., and that the company had produced the previous month 95 tons.

The complete returns for Rhodesia are not available, but the following monthly productions are given:[2]

January 1914	58.84	tons
April 1914	65.00	tons
December 1914	69.24	tons
January 1915	26.5	tons

No production was reported for May, June, and August, 1914; the production seems to have been continued at about the same rate, the difference in amount reported being due to transportation difficulties.

The value of the production is given for 1913 as £5,224 and for 1914 as £8,612.[3]

Asbestos has been obtained in Kuruman, Hay, and Prieska divisions of Cape Colony. During 1912 twelve companies were producing on the tributing system; but since then little has been printed concerning the condition of the industry.

[1] See *So. Afr. Min. Jour.*, May 2, 9, 16, 1914.
[2] *So. Afr. Min. Jour.*
[3] *So. Afr. Min. Jour.*, Feb. 6, 1915.

ASPHALT

By Clifford Richardson

Asphalt is a solid form of native bitumen, using the term solid in its ordinary and not in its scientific sense. It is found occurring in nature as such and is also prepared industrially from certain petroleums as a residual by the removal of the more liquid and volatile portions by careful distillation. Asphalt is, in both cases, a derivative of petroleum, produced either by natural causes at ordinary temperatures or industrially by the hand of man, at high temperatures.

Asphalt does not originate as such but is the result of slow metamorphosis in nature of certain types of petroleum, which takes place usually at some depth below the surface of the earth or, on a smaller scale, at the surface by the conversion of effusions of oil into more or less solid bitumen. Asphalt, therefore, originates in petroleum. However, not all petroleums form asphalt.

For statistical purposes the asphalts must be divided into the two classes, natural and artificial. The natural asphalts of industrial importance are obtained, at present, chiefly from the celebrated pitch lake in the Island of Trinidad, B. W. I., and from a similar deposit in the state of Sucre, Venezuela, known as the Burmudez Pitch Lake.

The residual or artificial asphalts are the product of the removal by distillation of the more volatile portions of asphaltic or semi-asphaltic petroleums, so called because they yield such residues, which are widely distributed in the western hemisphere; in California, where the oils are of a highly asphaltic nature; in Texas, Oklahoma and Illinois, where they are of a semi-asphaltic nature; in Mexico, of quite a unique nature, and in Trinidad and Venezuela, underlying the asphalt deposits, which are highly asphaltic. Asphalt plainly originates in petroleum of this type.

Accurate statistics as to the production of the native asphalts are available as collected by the U. S. Geological Survey.

Those for the residual asphalts are far less satisfactory, since the classification of this type of materials is not well defined, all liquid and solid residuals being reported in a manner which makes it impossible to differentiate them according to consistency.

The total production by classes as given by the U. S. Geological Survey for the years 1911, 1912 and 1913 are as follows:

PRODUCTION OF ASPHALT 1911–1913, BY VARIETIES
(In short tons)

Variety.	1911.		1912.		1913.	
	Quantity.	Value.	Quantity.	Value.	Quantity.	Value.
Bituminous rock	(a) 42,654	(a) $159,670	(a) 54,762	(a) $173,018	57,549	$173,764
Maltha	8,574	125,966	474	3,518	.....	.....
Wurtzilite (elaterite)	610	30,500	(d) 8,452	(d) 115,620	.....	.....
Gilsonite	30,236	486,114	31,478	573,069	35,055	576,949
Grahamite	5,000	15,000	(e)	(e)	.....	.....
Total	87,074	817,250	95,166	865,225	92,604	750,713
Manufactured or oil asphalt (c)	277,192	3,173,859	354,344	3,755,506	436,586	4,531,657
Total	364,266	$3,991,109	449,510	$4,620,731	529,190	$5,282,370

(a) Includes small output of mastic. (c) This item includes material previously referred to as refined bitumen. (d) Includes grahamite. (e) Included in wurtzilite.

The data are open to criticism, as has been said, because of their very loose classification. The term maltha is of very indefinite meaning. It would, ordinarily, be applied to a heavy natural liquid bitumen, which is hardly an article of commerce. The heading "Manufactured or Oil Asphalts" is too inclusive to permit of any differentiation between liquid and solid material. Wurtzilite, gilsonite, grahamite and ozokerite, while native bitumens, should hardly be included in the same class of material as asphalts, except as they are all to be regarded as solid bitumens.

The data which are available demonstrate the very large increase in the amount of residual products from petroleum, including both liquid and solid products, in recent years. They are used to a large extent, the solid material for paving purposes and the liquid and semi-liquid for road surfaces to enable them to resist the destructive action of the modern motor car which has produced a most serious deterioration of our ordinary country roads. The liquid forms are largely used for abating the dust nuisance which has become acute with the advent of the motor car.

At present there is no production of natural asphalt, as such, in the United States, the production in this country being confined to residual pitches and to asphaltic sands, although deposits of natural asphalts occur which can not be worked profitably commercially.

The solid native bitumens, of a nature quite different from asphalt, produced in the United States on a commercial scale of any considerable extent are gilsonite and grahamite. Both are unique materials found only in this country. They are of industrial importance, not only for highway construction but for the manufacture of varnishes and japans.

Deposits of sand asphalt which are worked to some extent are found in California, Kentucky and Oklahoma, but their production is limited to local demands owing to the cost of transporting the mineral matter, with which the bitumen is associated, to any great distance.

According to the statistics of the U. S. Geological Survey, the imports of asphaltic materials into the United States for the years 1908 to 1913 inclusive are as follows:

ASPHALT IMPORTED FOR CONSUMPTION INTO THE UNITED STATES, 1908–13
(In short tons).

Year.	Crude.		Dried or Advanced.		Bituminous Limestone.		Total.	
	Quantity.	Value.	Quantity.	Value.	Quantity.	Value.	Quantity.	Value.
1908	137,808	$532,297	7,642	$67,364	6,224	$20,758	151,674	(a) $624,979
1909	128,109	511,631	10,087	94,146	6,409	18,440	144,605	(a) 633,205
1910	162,435	588,206	20,180	178,704	3,696	9,301	186,311	(a) 785,963
1911	167,681	572,198	20,461	184,954	8,180	23,468	196,322	789,236
1912	193,645	726,345	20,707	177,992	3,976	15,808	218,328	921,145
1913	(b) 207,033	738,452	(c) 14,750	133,336	6,395	38,823	228,178	910,611

(a) Imports for 1908 include $4560 of manufactures, 1909, $8988; 1910, $9752. (b) Includes dried or advanced asphalt for last 3 months of 1913. (c) Last 3 months of 1913 included in crude asphalt.

According to the report of the Survey for 1913: "The ozokerite imported amounted to 4,472,708 lb., valued at $388,461, in 1911. This increased to 6,352,003 lb. in 1912, valued at $488,894. The import price declined from 8.7 cts. a lb. in 1911 to 7.7 cts. a lb. in 1912. In 1913 the quantity imported rose to 7,141,514 lb., valued at $549,992."

The Survey also presents in its last report the following data in regard to the source of material imported into the United States for the last 3 years:

ASPHALT IMPORTED INTO THE UNITED STATES DURING THE FISCAL YEARS ENDING JUNE 30, 1911 TO 1913, BY COUNTRIES
(Long tons)

Imported From	1911.		1912.		1913.	
	Quantity.	Value.	Quantity.	Value.	Quantity.	Value.
Europe:						
Belgium	364	$5,498	420	$2,914	89	$538
France	119	1,598	248	2,390	.....	.....
Germany	2,091	17,576	2,586	22,111	1,898	16,444
Italy	6,099	17,636	5,515	22,873	4,619	18,874
Netherlands	.....	41	.....	.....	100	598
Switzerland	750	5,783	1,453	9,863	1,235	8,272
United Kingdom	297	6,876	434	5,278	7,721	18,736
North America:						
Canada	36	600	94	2,351	1	28
Mexico	32	457	581	11,089	64	482
West Indies:						
British	94,594	405,735	115,884	475,299	108,216	438,362
Cuba	14,027	73,233	12,405	68,879	9,696	57,804
Danish	.....	.....	.....	.....	.....	.....
South America:						
Colombia	45	1,639	11	1,216	.....	.....
Venezuela	34,104	170,683	53,922	200,074	78,221	390,907
Asia:						
Turkey	.....	.....	.....	.....	3	639
Oceania	10	391	25	967	10	396
Total	152,568	$707,746	193,578	$885,304	211,873	$952,080

The preceding data reveal the fact that the very large majority of the asphalt imported into the United States, as such, is derived from the deposits in Trinidad and Venezuela amounting, according to the data given, to 186,000 tons in 1913.

The year 1913 is distinguished by the fact that under the law becoming operative Oct. 4 of that year all asphalts, except manufactured products, have been imported free of duty since that date.

According to *The Mineral Resources of the United States*, 1913, the exports of asphalt from Trinidad during the last 7 years have been as follows:

TOTAL EXPORTS OF ASPHALT FROM TRINIDAD, 1907–1913
(Short tons)

Year (a).	To United States.			To Europe.		
	Lake.	Land.	Total.	Lake.	Land.	Total.
1907	97,243	4,642	101,885	59,987	224	60,211
1908	92,212	5,886	98,098	51,183	1,276	52,459
1909	97,629	13,787	111,416	49,345	224	49,569
1910	109,198	9,274	118,472	65,778	150	65,928
1911	103,590	8,040	111,630	67,105	.....	67,105
1912	95,111	8,600	103,711	85,299	.....	85,299
1913	123,873	1,400	125,273	104,153	.....	104,153

Year (a).	To Other Countries.			Grand Total.
	Lake.	Land.	Total.	
1907	.....	230	230	162,096
1908	.....	.....	.....	150,557
1909	.....	.....	.....	160,985
1910	.....	.....	.....	184,400
1911	983	.....	983	179,718
1912	486	.....	486	189,496
1913	605	.....	605	230,031

(a) Ending Jan. 31 of year succeeding.

The importance of this well-known deposit is demonstrated and its increasing use in Europe, as well as in the United States, is also shown.

Attention should be called to the fact that large amounts of residual asphalt have been made in the United States from petroleum imported in its crude form from Mexico, in regard to which statistics, apparently, are not available, and great confusion has resulted from the fact that these residuals are not sharply differentiated according to their consistency so that they may be properly classified as residual asphalt and residual oil. It is to be hoped that statistics of this kind will be collected by government authorities in subsequent years.

With the demand for asphalt for the construction of pavements

and road surfaces which will resist the destructive action of the motor car, the use of asphalt is increasing annually and will no doubt continue to do so.

WORLD'S PRODUCTION OF ASPHALT AND BITUMINOUS ROCK (a)
(In metric tons)

Asphalt.

Year.	France.	Germany.	Hungary.	Italy. (c)	Spain.	Trinidad. (b)	United States. (e)	Total.
1905...	20,000	115,267	247	26,838	5805	116,735	24,737	309,629
1906...	28,231	138,059	4111	34,386	6229	132,381	44,430	387,827
1907...	33,000	126,649	3920	38,568	8643	147,051	36,656	394,487
1908...	41,000	89,009	4818	34,761	9231	136,583	37,389	352,791
1909...	44,800	77,537	5054	39,165	6582	146,013	39,640	358,791
1910...	38,500	81,208	4994	41,705	8473	161,587	31,159	367,626
1911...	38,000	81,902	3861	50,179	3495	163,080	40,307	380,824
1912...	31,535	96,112	4460	52,707	5387	176,077	37,570	403,888
1913...	30,892	.....	3024	56,750	.....	208,164	31,810	.....

Bituminous Rock.

Year.	Austria.	France.	Hungary.	Italy.	Spain.	United States.	Total.
1905.....	4363	191,509	19,372	106,586	5,725	32,337	359,892
1906.....	2840	196,375	34,664	130,825	7,794	21,848	394,346
1907.....	3858	177,000	33,096	161,126	8,219	41,301	424,600
1908.....	3695	171,000	72,972	134,163	12,373	33,901	428,104
1909.....	2975	169,000	(d)70,000	111,067	5,284	50,243	408,569
1910.....	1066	170,000	(d)70,000	162,212	7,795	58,581	469,654
1911.....	1740	169,697	.....	188,133	6,500	38,704	.....
1912.....	4234	312,000	.....	181,397	.....	49,691	.....
1913.....	3026	324,610	.....	171,097	.....	(f)52,220	.....

(a) Statistics of production in Barbados, Cuba, Mexico, Russia, Switzerland, and Venezuela are not available. (b) Exports. (c) Including mastic and bitumen. (d) Estimated. (e) Previously the U. S. statistics included oil asphalt. This is now omitted, leaving only the natural asphalt. (f) Includes some maltha.

The value of these data is very much limited by the fact that the reports from the various countries do not differentiate sufficiently the purer forms from those which are associated with large amounts of mineral matter.

BARYTES

By Avery H. Reed

The production of crude barytes in the United States in 1914, according to figures compiled by the United States Geological Survey, was 51,547 short tons, valued at $153,715. Compared with the production of the preceding year, 1913, which was 45,298 short tons, valued at $156,275, this was an increase of 6,249 tons in quantity and a decrease of $2,560 in value. The average price per ton reported to the Survey in 1914 was $2.98, compared with $3.45 in 1913. The total quantity of refined barytes reported as sold by mills in 1913 was 37,033 short tons, valued at $525,300, and in 1914 there was reported 34,315 short tons, valued at $447,358, a decrease of 2,718 tons in quantity and in value of $77,942, as compared with the preceding year.

PRODUCTION OF CRUDE BARYTES IN U. S., 1911–1913
(By states, in short tons)

State.	1911.			1912.			1913.		
	Quantity.	Value.	Av. Price per Ton.	Quantity.	Value.	Av. Price per Ton.	Quantity.	Value.	Av. Price per Ton.
Missouri	21,500	$81,380	$3.79	24,530	$117,035	$4.32	31,131	$117,638	$3.78
Tenn. and Kentucky.	8,819	20,053	2.27	(a) 3,718	8,682	2.34	(a)2,098	3,598	1.70
Other states(b)	8,126	21,359	2.63	9,230	27,796	3.01	12,069	35,069	2.81
Total	38,445	122,792	3.19	37,478	153,313	4.09	45,298	156,275	3.45

(a) Production of Tennessee; no production of barytes reported for Kentucky in 1912 and 1913.
(b) In 1910 and 1912, Georgia, North Carolina, and Virginia; in 1911, Georgia, North Carolina, South Carolina, and Virginia.

In 1912 the United States imported 26,186 short tons of crude barytes, valued at $52,467, or $2 per ton; in 1913, 35,840 short tons of crude barytes, valued at $61,409, or $1.71 a ton; and in 1914 the imports were 21,807 short tons, valued at $46,782, or $2.14 a ton.

IMPORTS OF BARIUM PRODUCTS, 1914
(Fiscal year, ending June 30)

Product.	Quantity.	Value.	Declared Value per Unit.
Baryta, sulphate of, or barytes including baryta earth:			
Unmanufactured tons (2240 lb.)	32,550	$63,260	$1.94
Manufactured tons (2240 lb.)	5,379	42,625	7.93
Blanc fixe, or artificial sulphate of barytes, and satin white, or artificial sulphate of lime, pounds	4,752,474	60,641	0.013
Lithopone, pounds	7,245,151	218,133	0.03
Barium carbonate, pounds	4,995,451	46,425	0.009
Barium binoxide, pounds	6,085,798	330,139	0.054
Barium chloride	6,110,386	67,563	0.011

In the United States the principal sources of supply of barytes are the Missouri and the Appalachian districts. In 1912 Missouri furnished about 65 per cent. of the total, and in 1913 the state furnished between 68 and 69 per cent. of the total production of the United States. But in 1914 the impetus given to American production by the European war has been greater in the Appalachian region than in the Missouri field, so that the former district has come forward with a larger per cent. of total production than it used to maintain.

The Missouri district embraces deposits in Washington, St. Francois, Franklin, and Jefferson Counties, of east-central Missouri, and Benton, Morgan, Miller, and Cole Counties in the center of the state. Practically all the barytes, locally known as "tiff," is mined from open pits and shallow shafts. Washington County has generally afforded about 75 per cent. of the total production of the state. But in Jefferson and Franklin Counties barytes occurs in fissures associated with galena, some of which fissures have, according to report, been worked to a depth of 500 ft. And apropos of barytes mineral association, in Benton and Cole Counties, Mo., there occurs barite-blende ore in commercial deposits, but which presents difficulties in mechanical separation and which has generally been handled by special processes of concentration, such as decrepitation, electrostatic separation, etc. In June, 1914, there was a patent granted to Charles J. Greenstreet,[1] of Webster Groves, Mo., for the separation of these minerals by mixing them with a salt such as chloride, sulphate or bisulphate of sodium and fusing the mixture. Under those conditions it is claimed the barytes is mechanically combined and held in suspension with the molten salt of sodium, while the blende is unaffected. And it is claimed that in practice the mixture eventually separates into two layers with the salt and barytes on top, and so a separation can be made. Further, that on dissolving the salt, barytes is again precipitated.

The principal operators and barytes merchants in the Missouri field are: Nulsen, Klein & Kraussee Mfg. Co., general offices and factories, St. Louis, Mo., and Lynchburg, Va.; Point Milling & Mfg. Co., general offices, mills and mines, Mineral Point, Mo.; J. C. Finck Mineral Milling Co., St. Louis, Mo.; and Geo. C. Mepham & Co., East St. Louis, Illinois. The Missouri district serves the central interior states as well as the western states, in which territory the imported article is at a disadvantage because of high freight rates from the eastern seaboard. Likewise, in ordinary times, little of the Missouri barytes product finds its way to seaboard on account of prohibitive eastern freight rates; but no doubt considerable Missouri barytes has been marketed in the East since the war in Europe has been on and importations have been curtailed.

[1] U. S. Pat. 1101115.

The Missouri barytes finds its way to the ultimate user principally in the ground form. There is but one concern in the usual territory served by the Missouri market, that is known to the writer, which uses crude lump or gravel barytes. This is the Chicago Copper & Chemical Co., Chicago, Ill., who use the commodity in that form in the manufacture and preparation of other barium chemical compounds.

The Appalachian district embraces Virginia, Kentucky, Tennessee, North Carolina, South Carolina, Georgia, and Alabama; and barytes deposits of possible economic importance are known to occur in Pennsylvania and in Maryland, although there is no report of any production having been made from these two states in late years. Likewise the barytes deposits in Alabama have not been worked since 1906, but there are stated to be workable deposits of barytes still in Alabama, in Calhoun, Etowah, and St. Clair Counties in the northeastern part of the state, and in Bibb County, near the center.

In Bartow County, Georgia, and within economic wagon hauling distance of Cartersville, there are residual deposits of barytes, resulting from disintegration of Cambrian and Ordovician rocks. It is known in the market as a good grade of barytes, and the principal objection to Georgia barytes is ocher contamination, which is very difficult to eliminate by washing or other mechanical dressing and preparation for grinding. In the crude form and for chemical manufacturing purposes the ocher contamination is not such a serious objection. Nulsen, Klein & Kraussee Mfg. Co. report that they have been operating their Georgia barytes mines more satisfactorily since the summer of 1914 than for some time previous. Mine product of this concern has been going to their Lynchburg, Va., plant for finishing in ground form for the open market. The Krebs Pigment & Chemical Co., Newport, Del., has been reported as having purchased 40 acres of barytes lands on the Western & Atlantic R. R., near Cartersville, Ga., which they would develop to produce 15,000 tons crude barytes annually, with intended mine production to begin June, 1915.

There are several large vein deposits of barytes located in South Carolina, in Cherokee County, in the northern part of the state near the North Carolina border, but the grade of ore is objectionable on account of the high content of silica, averaging about 5 per cent. Mr. Stephen Taber, of the University of South Carolina, reports that one company operated in the state in 1914, and made a small production of barytes, at Cherokee Chemical Co.'s mine and mill at King's Creek.

Dr. Joseph Hyde Pratt reports that the following companies produced barytes in North Carolina in 1914: J. F. Harrisses, Hot Springs or Bluff, Madison County; Ben. W. Gahagan, Walnut, Madison County;

and Carolina Barytes Co., Stackhouse, N. C., also 100 William Street, New York, N. Y.

The Carolina Barytes Co. also operated in eastern Kentucky, where they own mines, and a finishing-grinding plant was operated at Nicholasville, Ky. And there has been reported considerable activity in the eastern Kentucky barytes district in the latter part of 1914. Prof. C. J. Norwood, in a press report Nov. 10, 1914, to the *Louisville Herald*, states: "Central Kentucky is the greatest barytes field in this country, and one of the few immediately helpful results of the war in Europe is that the Kentucky barytes deposits seem likely to receive the attention from American manufacturers that their industrial value warrants." Several new companies were formed and incorporated to mine barytes in eastern or central Kentucky toward the close of 1914 and early in 1915. Some of them are: Kentucky Barytes Co., Louisville, Ky.; James Eastin, Weiman & Co., Pittsburgh, Pa.; and E. C. Young, Charleston, W. Va. The latter, it is generally understood, represents the interest, directly or indirectly, of the Rollin Chemical Co., Charleston, W. Va., and 100 William Street, New York, N. Y., which is stated to be a branch of the Hedworth Barium Co., Ltd., New Castle-on-Tyne, England. "The English house is the original and the largest in the world in its line, which is the manufacture of barium binoxide, the raw material for hydrogen peroxide. This will be the first time that binoxide of barium has been manufactured in the United States."—*Manufacturers' Record.*

The same publication has further to state, regarding the Rollin Chemical Co., that that interest bought ground in Charleston, W. Va., in April, 1914. Of the 10-acre tract secured, present buildings will cover 1½ acres. That the company considers this but an initial development is indicated by the fact that negotiations were under way for an increased acreage. The present plant will employ from 400 to 600 workmen and will have a capacity of 3000 tons of binoxide of barium. It is stated that the entire product of the first year has been sold.

This and various other products of the company's plant at Charleston are all products of barytes which now are being obtained principally in this country, the first contracts covering a supply from east Tennessee. By way of comment, however, the president of the Rollin Chemical Co., Mr. Hugh Rollin, has informed the writer that ultimately no doubt, and after the war in Europe is over, a large part of the raw material used by this concern will come from abroad, which fact was a point, possibly, in favor of Charleston for location because of opportunity to obtain a favorable freight rate on imported barytes via Newport News, Va. Other products of the Rollin Chemical Co. will be barium oxide, used in the arts; amorphous anhydrous barium hydrate, used in the

paint trade; barium hydrate, used in water softening and in numerous trades, including the paint trade, sugar trade, etc.; barium sulphide, used in the manufacture of lithopone; nitrate of barium, used in the manufacture of explosives; chloride of barium, used principally in the paint trade and as a raw material for other manufactures. Binoxide of barium is the underlying base of hydrogen peroxide, about $8,000,000 worth having been used in the United States during 1914 for medicinal purposes and for bleaching silks, linens, straws, etc. The Rollin Chemical Co. has stated further to the writer that it would, in the near future, add to the plant processes for the manufacture of various compounds of strontium and, to that end, believed they already had in hand a substantial outlook for domestic raw supply of strontium ores. Kentucky barytes carries an appreciable percentage of strontium sulphate, and Owen County, Ky., is accredited with having economic deposits of celestite.

Mining Press, Feb. 6, 1915, states: "Strontium is of little importance; everybody knows that its salts are used to make the red fire of fireworks displays and also the fuses used on railways. It occurs both as the carbonate and sulphate; the former is more desirable, but it is difficult to procure. There are some strontium sulphate deposits in this country, especially near Gila Bend, Ariz., and in San Bernardino County, Cal. As our previous supplies of strontium salts have chiefly come from Germany, inquiry has naturally turned toward domestic sources of supply, but nothing of much importance seems to have developed as yet. As the total imports of strontium salts in 1913 were less than $3000, there are apparently no fortunes to be made out of it." Nevertheless, the strontium salts market had advanced 200 per cent. in December, 1914, over the market of early summer of the same year.

The barytes deposits of central Kentucky are described in detail by F. J. Fohs, in Series IV, Vol. I, Part 1, Kentucky Geological Survey. Western Kentucky Barite Co. was formed and undertook to exploit barytes deposits in Crittenden and Caldwell Counties, western Kentucky, in 1914, and shipped two cars of crude barytes each from Ray & Lower mines, Hoosier ("Commercial") mine, and Bibb & Stephenson mines; but the venture of mining vein barytes proved unprofitable on account of limited output and demand for the crude commodity in the market territory that could be served favorably.

Virginia was once very prominent for producing a large percentage of the domestic barytes of the United States, and produced a grade of barytes that was as good as the German imported and which was in consequence in great demand. The Virginia barytes mines at Evington, Campbell County, as well as at Toshes and at Sandy Level, Pittsylvania County,

have had the greatest development and have in the aggregate produced more high-grade barytes from veins than perhaps any other vein barytes deposits in the United States.

The barytes mines near Evington, Va., have been worked to depths of 50 to 160 ft., and have been about exhausted so far as ore in sight has been determined. In 1914 Hewitt mine and Sanders mine each were worked to some extent, and old dumps at both of these and other mines about Evington were re-worked and considerable barytes produced and shipped to Lynchburg, Va.

At Toshes and at Sandy Level, Va., vein mining is reported to have been prosecuted to depths of 75 to 200 ft., without having actually exhausted anything like all ore in sight; but mining has waned because of the difficulty of holding the ground and because of water troubles. Some activity was reported at both these localities in 1914, both in winning new ore and in cleaning old dumps. The product in the main went to Lynchburg, Va., for finishing by grinding.

In the other barytes localities of the Piedmont region of Virginia, in Prince William, Louisa, and Bedford Counties, as well as in the Valley barytes region of Virginia, comprising Montgomery, Russell, Smyth, and Tazwell Counties, the writer could not learn of any appreciable activities going on in 1914. It is more than likely that the Valley region, nevertheless, came forward with renewed activity and produced considerable crude barytes. This region affords residual barytes derived from Cambrian and Ordovician rocks; and it is the residual barytes ore of the United States that makes up the principal production of the country, and justly so, because that variety of ore can generally be mined cheaply and because it is usually produced cheaply by contract mining.

Tennessee has both vein deposits and residual deposits of barytes. The vein deposits occur in Cocke and Sevier Counties, next to the North Carolina border and southeast of Knoxville. These deposits are promising and the barytes is of the highest quality, but lack of transportation has prevented their development. Around Sweetwater, Tenn., are located important residual deposits of barytes, which have played an important rôle in the barytes market in the past and which were worked extensively in 1914 and perhaps in that year made their greatest production.

Thomas L. Watson and J. Sharshall Crasty have published a most excellent treatise on the *Barite* of the Appalachian States.[1]

There are barytes deposits in Mariposa County, Cal.; in Clark, Elko, Mineral, and Nye Counties, Nev.; in Blaine County, Idaho; and

[1] *Bull. Amer. Inst. Min. Eng.*, 98.

in Alaska. There was no incentive to work any of these deposits in 1914, because there is very little trade in barytes in the western states. In *Bulletin* 592–D, U. S. Geological Survey, E. F. Burchard has described a recent discovery of barytes on one of the Castle Islands, 40 miles northeast of Wrangle, Alaska, and Mr. Burchard has estimated more than 60,000 tons of barytes in sight.

Barytes generally reaches the ulterior market in the ground form, and as such is used principally by the paint trade and in the rubber industry. There are several minor uses for ground barytes in other arts and manufactures. Strictly chemical plants that use barytes for conversion into other barium compounds use crude barytes, principally on account of its cheapness compared with the ground and finished product.

The principal eastern barytes operators and merchants are: Nulsen, Klein & Kraussee Mfg. Co., Lynchburg, Va.; Carolina Barytes Co., 100 William Street, New York, N. Y.; and Cherokee Chemical Co., King's Creek, S. C., all of whom mine, finish and market barytes. Durex Chemical Works, general office 320 Fifth Ave., New York, N. Y., and works and mines Sweetwater, Tenn., are the successors of the David Gilman plant at Sweetwater. They claim to make all the customary barium compounds, among other industrial chemical preparations. The Solvay Process Co., Syracuse, N. Y., have been manufacturing barium chloride and is reported as planning to make other barium compounds.

STATISTICS OF BARYTES IN THE PRINCIPAL COUNTRIES
(Metric tons)

	1910.	1911.	1912.	1913.	1914.
Austria-Hungary (exports)					
Barium chloride	4,344	3,741	3,659	4918	.....
Barytes	13	12	2,690	753	.....
Belgium (production)	4,960	25,200	32,400	12,000	.....
Canada (production)	*Nil.*	50	421	582	555
France (production)	11,632	10,064	13,620	.....	.....
Baden (production)	13,832	15,014	15,871	16,445	.....
Bavaria (production)	24,711	26,234	27,199	27,199	.....
Germany (exports)					
Barytes	114,264	128,452	142,681	158,065	.....
Barium white	5,528	6,834	8,242	7,647	.....
Barium chloride	6,403	6,180	8,096	5,649	.....
Barytes (imports)	5,782	7,926	18,666	19,466	.....
Italy (production)					
Barytes, ground	.....	.....	.....	.....	.....
Barytes, crude	14,420	13,620	13,420	12,970	.....
Barytes (imports)	1,777	2,024	1,986	1,771	1,409
Barytes (exports)	150	353	381	234	210
Spain (production)	476	635	1,096	.....	.....
Sweden (imports)	625	607	644	610	.....
United Kingdom (production)	43,637	43,232	43,453	48,792	46,675
United States (imports)	22,536	21,195	27,093	36,878	.....
United States (production)	38,998	34,887	34,009	41,105	.....

Africa.—About 200 miles from Sphax, directly opposite Cattinao, a town on the Island of Sicily, is found an important deposit of barytes.

Most of the production goes to Spain and is shipped as "Lilly White," a very high-grade ground product.

Canada.—Barytes is found in many parts of the country, the best locations being those at Five Islands, Colchester County; River John, Pictou Country; Lake Ainslie & Mabou, Inverness Country, Nova Scotia; in the Township of Hull, Quebec; and on McKellar Island, Lake Superior, Ontario. The latter deposit is some 19 miles from Port Arthur, is of very large dimensions, and contains an excellent grade of mineral. Barytes is a common constituent of mineral veins along the north shore of Lake Superior. The annual output of barytes fluctuates tremendously, and may be said to lie between 500 and 4000 tons, although (in some years) practically nothing has been shipped.[1]

England.—Valuable barytes deposits occur in this country, some of which are residual but most of which are veins, with which latter usually are associated ores of lead, zinc, and tin in Cornwall; and such ores are generally cobbed out of the barytes, or the barytes cobbed from the metallic ores. The barytes deposits are principally located in the north of England, in the counties of Durham, Northumberland, Cumberland, and Westmoreland. The grade is good, and nearly all of the production is ground and exported from Hull, principally to Germany, Italy, and Austria, and very little to the United States. Nominal output is about 150,000 tons annually, and it is suspected the continental war reduced the output as much as one-half in 1914. England has the only economic deposit of witherite, carbonate of barium, in the world. This important deposit is located at Fourstones, Northumberland County, and is owned and operated by the Hedworth Barium Co., Ltd. Three grades of witherite are shipped: (1) 92 per cent. carbonate; (2) 96 per cent. carbonate, and (3) 98 per cent. carbonate. Ruling prices in the open market have been nominally $20 to $25 per ton for lower grades and anything above for very high-grade product, and the market has simply soared since the war in Europe has been on.

Germany.—This country is known to have unlimited deposits of barytes, and German barytes ranks perhaps the highest grade of any in the world. On account of being cut off from importation of Rio Tinto pyrites, Germany is reported to have been using barytes largely since the war has been on in the manufacture of sulphuric acid. In the process developed, the sulphate first is reduced with coal to sulphide and the latter decomposed with carbonic acid into carbonate of barium and hydrogen sulphide, which in turn is converted into either sulphurous acid or elemental sulphur. It should be taken into consideration that the exports of barytes and barium compounds might mislead, because Ger-

[1] *Min. Jour.*, Feb. 15, 1915.

many imports much barytes, especially from England, and in merchandising a large part of such imports are exported.

NOTE.—Close to the borders of Switzerland, in Germany, there are barium carbonate springs that flow naturally and the waters from which are concentrated, washed, filtered and the resultant concentrate used in Germany to manufacture barium binoxide.

Ireland.—At Larn there is a very good deposit of vein barytes, affording high-grade product which is all shipped crude and is chiefly exported to England and the European continent and rarely any exported to the United States.

Norway.—Barytes is produced in this country mainly as a by-product of lead mining, and mechanical separation and concentration, even the electrostatic process, are used.

BISMUTH

Bismuth, so far as we can learn, was produced in 1914 in quantity by only two firms in the United States: The U. S. Smelting, Refining & Mining Co., as a by-product of electrolytic lead refining, and the American Smelting & Refining Co., which extracts the bismuth (by electrolysis, it is claimed) from an enriched bullion obtained by steam pattinsonizing. It has also been stated that the National Lead Co. recovers bismuth from its residues, but this report can not be confirmed.

The price in January, 1914, was $1.80 per lb. for foreign bismuth; $1.72 for domestic. Owing to interruption to Bolivian and Australian trade it jumped to $2.85@3, and closes the year about $2.85.[1]

The production in the United States in 1913 was estimated at 185,000 lb. and for 1914 at 225,000 lb.

The separation of bismuth and copper as they occur in various metallurgical by-products, particularly those from electrolytic lead refining, is covered in a recent patent of William Thum.[2] The metals are supposed to have been brought to the state of oxides, as they would occur, for instance, in a cupeling-furnace slag.

This oxide slag, crushed to 4 mesh or finer, is mixed with sodium sulphate carrying an amount of sulphur in excess of that required to matte the copper, and carbon in excess of that required to reduce the salt cake to sodium sulphide, and all of the oxides to metal. This mixture is then smelted at a temperature between 2500° and 3000° F., giving three layers: metallic bismuth, copper matte, and a soda slag.

Probably the larger part, but not all, of the bismuth in copper ores goes out through the smelter stacks. A table given by Eilers[3] shows the following recoveries of bismuth from blister copper when refined electrolytically:

RECOVERY OF BISMUTH PER TON OF BLISTER COPPER

Location of Smelter.	Bismuth.	Location of Smelter.	Bismuth.
	Pounds.		Pounds.
Garfield, Utah [a]	6.1	Tacoma, Wash. [e]	5.7
Steptoe, Nev. [b]	0.33	Aguascalientes, Mexico [f]	4.0
Omaha, Neb. [c]	18.6	Cerro de Pasco, Peru [g]	13.5
Mountain, Cal. [d]	27.3	Mount Lyell, Tasmania [h]	4.3

[a] The blister copper comes principally from the Bingham "porphyry" mines.
[b] From the "porphyry deposits" of the Nevada Consolidated Copper Co., at Ely.
[c] Principally from concentrated copper-lead mattes shipped from lead-silver plants of the Rocky Mountain region to the converters at the Omaha lead refinery.
[d] From ores of the Mountain Copper Co. at Iron Mountain, Shasta County, Cal.
[e] From Pacific coast and Alaska copper ores.
[f] From gold and silver ores low in copper, from all parts of Mexico.
[g] From copper and lead mattes from local deposits.
[h] From low-grade local copper deposits.

[1] *Eng. Min. Jour.*, Jan. 9, 1915.
[2] U. S. Pat. 1098854.
[3] Notes on Some of the Rarer Metals in Blister Copper. *Bull. Amer. Inst. Min. Eng.*, **78**, pp. 999-1000, June, 1913.

With the adoption of the Cottrell process of fume precipitation, another large potential source of bismuth is being provided; and should it prove feasible to separate the bismuth from the mass of dust and fume, it seems probable that enough bismuth will be produced to supply the present American market entirely and possibly to provide for larger markets developed by cheaper bismuth. The quantity of bismuth now produced in this country is comparatively large and has apparently made a considerable difference in the imports, but without making a market for the miner or reducing the price to the consumer.

The following table gives the imports for the fiscal years since 1905:

Year.	Quantity, lb.	Value.
1905	153,668	$305,471
1906	243,926	378,652
1907	215,647	262,775
1908	225,833	313,919
1909	176,729	274,662
1910	200,221	316,838
1911	178,298	321,360
1912	166,980	305,282
1913 (a)	151,030	257,176
1914	133,190	241,448

(a) Dept. of Commerce.

The main foreign supply comes from Bolivia. The following table gives the output of Bolivia for recent years:

Year.	Quantity, Metric Tons.
1909	139
1910	134
1911	242
1912	263
1913	275

Production in Peru in 1913 amounted to 25,300 kilograms.

The next important source of foreign supply is Australia.

Bismuth occurs at Bamford in several different combinations, but almost always anhedrally; in the native or metallic condition as silver-white sub-micaceous masses subject to rapid tarnish to a golden bronze; as the dull lead-colored well-cleaved and frequently acicular sulphide; as amorphous carbonate, mostly mouse colored, sometimes dark yellow (when it probably contains tungstic acid), and often streaked or tesselated with dark gray; and, lastly, as yellow ochre, sometimes containing important amounts of tungstic and molybdic oxides. The bismuth minerals are found most plentifully in the cellular quartz rock surrounding the pipes, but they appear in quantity also among the vug fillings. Only very rarely do they penetrate the accompanying minerals, and it is presumed therefore that bismuth was the last metal thrown down. Bismuthinite is a common associate of molybdenite, with which it may be

interlaminated, thereby depreciating its value. The wolfram concentrate from one of the greisen shafts on the Trafalgar contains 15 per cent. bismuth, an altogether out of the common amount. Among the sulphides, galena from one of the Rose of Queensland vugs has been shown by assay to contain 2.8 per cent. bismuth, and the hand-picked copper ore of the Gillian and Bridge, assaying 16 per cent. copper, carried enough bismuth to render it unmarketable.[1]

PRODUCTION OF BISMUTH MINERALS IN AUSTRALIA
(Tons of 2240 lb.)

Year.	Queensland.		New South Wales.	
	Tons.	Value.	Tons.	Value.
1903	11.0	£2,523	21.7	£9,537
1904	20.9	3,581	40.3	12,329
1905	15.3	5,368	55.8	20,763
1906	6.5	1,882	25.9	5,700
1907	6.3	1,806	16.3	5,268
1908	22.7	10,595	8.7	2,017
1909	10.3	2,271	8.6	1,624
1910	21.0	9,708	6.4	2,004
1911	9.8	5,525	7.9	1,800
1912	5.0	2,835	5.8	1,210
1913	1.1	1,618	9.0	.....

Tasmania reported the production of 5 tons of bismuth ore in 1913 and 5.6 tons in 1914.

Properties and Uses.—Bismuth is a silver-white, lustrous metal of a specific gravity of 9.823. Its melting point is 268.3° C. In appearance bismuth resembles antimony but has a foliated structure. Upon solidifying, bismuth expands about 2.3 per cent., a property which makes the metal valuable in the production of stereotype plates. It is not affected by dry air, but in moist air becomes coated with a reddish powder. Heated in the atmosphere the metal burns, forming the trioxide Bi_2O_3. Hot sulphuric acid converts it into a basic sulphate. Bismuth alloys readily with other metals, and imparts to them the properties of hardness and ready fusibility. It is used in the production of fusible alloys, as an amalgam, with or without tin and lead, for silvering mirrors, and in the manufacture of electric fuses.

[1] *Queensland Govt. Min. Jour.*, Nov., 1914.

BORAX

By Samuel H. Dolbear

The borate mines of California continue to be the only source of borax in the United States, and during 1914 the production of colemanite remained about normal and seems to have been affected less by war conditions than other minerals.

A narrow-gauge railroad has been completed, connecting the Biddy McCarthy and the Monte Blanco Mines of the Pacific Coast Borax Co. with the Tonopah & Tidewater R. R. at Death Valley Junction. This represents an expenditure of about $400,000 and opens up some of the best deposits in the Death Valley section. These deposits had hitherto been inaccessible on account of difficulty in transportation. The Pacific Coast Borax Co. also built, during the year, a large calcining plant at Death Valley Junction to roast the lower grade ores before shipment to its refineries.

During the year, the Sterling Borax Co., under the management of Thos. Thorkildsen of Los Angeles, is reported to have mined about 15,000 tons of colemanite from its mines 6 miles from Lang in Los Angeles County. This one is divided into two grades. The first grade averages 31 per cent. anhydrous boracic acid, the second grade about 20 per cent. These ores are all roasted at the mine, eliminating thereby pandermite, clay, and water. On roasting, the pandermite and clay retain their original shape, while colemanite disintegrates to a fine powder and is separated from the impurities by screening.

During the year, the control of the Russell Borax Mining Co. was acquired by the Stauffer Chemical Co. Fifteen miners were employed here during the 7 months' operating season and a production of 3800 tons of colemanite ore resulted. This ore averages 37 to 38 per cent. anhydrous boracic acid.

A discovery of borax ore in the Kramer district about 4 miles from Rich Station on the Santa Fe Railroad was reported in 1913. Unconfirmed statements have been made that a vein of colemanite 40 ft. in thickness was found while drilling for water on a ranch at this place. It is regarded as significant that the property has been purchased by the Pacific Coast Borax Co.

Borax prices were somewhat higher in 1914 than during the previous year. Quotations for carload lots were at 4 to 4.25 cts. per lb. in 1914, as compared to 2.75 to 4 cts. in 1913.

The refining of borate ores into borax and boracic acid in the United States has been confined to the plants located at Bayonne, N. J., Brooklyn, N. Y., New Brighton, Penn., Chicago, Ill., and San Francisco. The refineries in San Francisco are operated largely for Pacific Coast and Japanese trade.

California borate ores supply most of the borax consumed in the United States, as will be seen in the following table of imports:

UNITED STATES IMPORTS OF BORAX, ETC.
(Fiscal years ending June 30)

Year.	Borax.		Borate of Lime, Etc.		Boracic Acid.	
	Pounds.	Value.	Pounds.	Value.	Pounds.	Value.
1909	341,058	$13,173	1,646	$167	230,968	$7,641
1910	9,058	1,479	19,201	1,855	416,842	13,610
1911	7,319	790	13,095	2,277	343,094	12,733
1912	6,409	604	22,784	3,856	276,496	10,540
1913	11,768	882	16,267	2,038	362,400	13,897
1914	466	64	220	29	527,201	22,390

The production of borate ores in California is given in the following table:

PRODUCTION OF BORATE ORES IN CALIFORNIA (a)
(In tons of 2000 lb.)

Year.	Tons.	Value.	Year.	Tons.	Value.	Year.	Tons.	Value.
1901	7,221	$982,380	1906	58,173	$1,182,410	1911(d)	53,330	$1,569,151
1902	(b)17,202	2,234,994	1907	53,412	1,200,913	1912(d)	42,315	1,127,813
1903	34,430	(c)661,400	1908	22,200	1,117,000	1913(d)	58,051	1,491,530
1904	45,647	(c)698,810	1909	16,628	1,163,960	1914(d)	62,400	1,464,400
1905	46,334	1,019,158	1910(d)	42,357	1,201,842			

(a) Reported by the California State Mining Bureau. (b) Mostly refined borax, whence the apparent discrepancy in value. Output of the other years is given as crude material. (c) Spot value. (d) U. S. Geol. Survey, crude. (e) Estimated.

The war in Europe has severely disturbed European borax operations, which are controlled by Borax Consolidated, Ltd., of London. This company, in addition to its French and English refineries, has refineries in Austria and has supplied all of the German refineries with borate ore from the Chilean mines.

Operation of the mines on the Sea of Marmosa has been interrupted by the participation of Turkey in the war. These mines, which are controlled by the British Syndicate, have for years been an important source of ore for French and Austrian refiners and were worked before the development of the South American deposits. Production from these Asia-Minor deposits is usually 14,000 tons per year.

The disturbed conditions in Europe have resulted in a considerable

increase in borax exports from the United States, particularly into Canada, which has heretofore been supplied from England. While there has been some falling off in domestic consumption, the stimulus of increased export business has resulted in the continuance of normal production in this country.

Chile.—A large part of the borate ores produced continue to come from Chile. These mines, which are located at Ascotan, near Antofagasta, contribute about 75 per cent. of the world's supply.

Argentine Republic.—The mines in this country are controlled by Borax Consolidated, Ltd., but none of the product has yet been shipped. In Coyaguaima and in the department of Cochinoca, Jujuy Province, the ore occurs as a double borate of lime and soda.

Some production is made each year in Jujuy Province, which, however, is only incidental to the assessment work required under the Argentine laws. At Tres Morros, the sun-dried borate carries 37 to 38 per cent. anhydrous boracic acid, 1800 tons of such material being produced in 1913. The expense of production is high on account of scarcity of fuel and lack of means of transportation. It does not seem likely that borate ores from this country will find their way into the world's markets until cheaper sources of the mineral have been exhausted.

Peru.—This country will probably become a producer of borates through an arrangement effected by Borax Consolidated with the Peruvian Government. This agreement provides for continuous production from deposits situated near Arequipa, and the construction of furnaces capable of treating 40,000 metric tons annually.

SOME OF THE PRINCIPAL SUPPLIES OF BORAX MATERIALS
(In metric tons)

Year.	Chile. (a)	Germany. (b)	Italy.			United States. (c)	Total. (d)
			Borax Refined.	Boric Acid.			
				Crude.	Refined.		
1899	14,951	183	709	2,674	129	18,466	37,112
1900	13,177	232	858	2,491	283	23,437	40,478
1901	11,457	184	544	2,558	347	6,550	21,640
1902	14,327	196	.....	2,763	.....	15,512	32,798
1903	16,879	159	.....	2,583	.....	31,232	50,853
1904	16,733	135	569	2,624	314	41,407	61,782
1905	19,612	183	(e)1,007	2,700	(e)749	42,036	66,287
1906	28,996	161	1,062	2,561	562	52,774	86,116
1907	28,374	114	881	2,305	466	47,945	80,085
1908	35,039	128	(e)1,024	2,520	(e)429	22,680	61,820
1909	32,218	149	(e)1,110	2,431	(e)578	37,589	74,075
1910	35,192	167	(e) 912	2,502	(e)695	38,426	77,894
1911	45,558	160	(e) 738	2,648	(e)444	48,381	97,929
1912	43,356	224	(e) 813	2,309	(e)760	38,388	85,850
1913	.....	.....	(e)1,071	2,410	(e)743	52,600	.....

(a) Prior to 1903, figures are for borate of lime exports. (b) Boracite. (c) Crude borax. (d) The total falls short of the world's supply, particularly because it fails to include the important production of Turkey. (e) Obtained by treating a part of the crude boric acid reported for the same year.

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BROMINE AND IODINE

The bromine industry in the United States is carried on principally in Michigan, Pennsylvania, Ohio and West Virginia. It is difficult to give exact figures of the output since the producers give no information in regard to the industry. The principal producers are the Dow Chemical Company in Michigan. The only plant in Pennsylvania was shut down and dismantled in March, 1914. The estimated production for the year 1913 was 794,500 lb., mostly in the form of bromides.

ESTIMATED PRODUCTION FOR 1914 IS AS FOLLOWS:

Michigan	746,000 lb.
Pennsylvania	10,000
Ohio	83,000
West Virginia	65,000
Total	904,000 lb.

The quantities used for metallurgical and medical purposes and in the arts was the same as in previous years. The only field in which the use of bromine is increasing is that of photography. This is due in large measure to the increasing motion picture business.

The following table shows the production of bromine in the United States for the period 1900 to 1913:

MARKETED PRODUCTION OF BROMINE IN THE UNITED STATES (a)

Year.	Quantity.	Value.	Year.	Quantity.	Value.
	Pounds.			*Pounds.*	
1898	486,979	$126,614	1906	1,283,250	$165,204
1899	433,004	108,251	1907	1,379,496	195,281
1900	521,444	140,790	1908	760,023	73,783
1901	552,043	154,572	1909	569,725	57,000
1902	513,893	128,472	1910	245,437	31,684
1903	598,500	167,580	1911	651,541	110,902
1904	897,100	269,130	1912	647,200	145,805
1905	1,192,758	178,914	1913	572,400	115,436

(a) U. S. Geological Survey.

Germany and England both export bromine. The supply of bromine in Germany so far exceeds the demand that the Bromine Convention has offered a prize to the discoverer of a process or compound which will lead to a greater consumption of bromine.

IODINE

No iodine is produced in the United States, although a possible source exists in the sea-weeds along the coast. The sea-weeds of California which are treated commercially for potash do not promise a large yield of iodine.

The imports of iodine are given in the following table:

Year.	Crude and Resublimed.	
	Pounds.	Value.
1909	12,961	$25,815
1910	771,090	1,051,060
1911	423,408	841,740
1912	379,311	737,109
1913	240,045	525,959
1914	463,333	951,308

The principal source of supply of iodine is the mother-liquor from the niter industry of Chile. The production for 1913 amounted to about 961,336 lb. Exports of iodine from Chile in 1913 amounted to 963,356 lb., valued at $1,874,071, of which Germany took 357,845, lb., valued at $695,619; the United Kingdom, 307,646 lb., valued at $598,489; the United States, 288,750 lb., valued at $562,723; and Belgium, 9376 lb., valued at $18,240.

Iodine imported into the United States is used in the production of iodoform, hydroiodate, and potassium iodate. The imports of iodide and hydroiodate for the fiscal years ending June 30 are shown in the table:

	Pounds.	Value.
1909	251	$508
1910	142	275
1911	272	519
1912	238	451
1913	120	239

The sea-weeds of Siberia are very rich in iodine. In 1910 plans for the establishment of a factory for the production of iodine from this source at Olga Bay were made by a Russian firm, but the Russian interests were purchased by a German chemical company which wished to limit competition.

Crude iodine is produced by a number of small producers along the southern coast of Japan. The principal producer is located at Hayama, about 20 miles from Yokohoma. The customs returns for 1912 show that in that year 22,772 lb. of iodine, valued at $44,977, was exported to Germany, Hongkong, Great Britain, and Belgium.

CADMIUM

Cadmium occurs associated with zinc, and is obtained as a by-product in the smelting of zinc ores by means of fractional distillation. The first producer of cadmium in the United States was the Grasselli Chemical Co., who placed its product on the market in 1906. At present there are two producers—the American Smelting and Refining Co. and the Grasselli Chemical Co. During the year 1913 the total production of cadmium was about 26,250 lb. The 1914 production is estimated at 25,000 lb. The Grasselli company obtains its cadmium from the cadmiumbearing blue powder; the American Smelting and Refining Co. gets its cadmium from the bag-house fume.

The imports of cadmium have steadily decreased since 1906 from a value of $10,552 to a value of $1,508 in 1913. The imports for the fiscal year ending June 30 are shown in the following table:

	Pounds.	Value.
1908	.....	$2,166
1909	.....	4,643
1910	3,083	1,657
1911	5,956	3,718
1912	6,396	4,603
1913	1,999	1,508
1914	1,543	1,239

The world's supply of cadmium comes chiefly from Upper Silesia Germany. According to Messrs. Speier, of Breslau, the production for the first quarter of 1913 totaled 9515 kg. During the corresponding period in the year 1914 the production was 8,815 kg. The production for 1912 totaled about 29,000 kg. Because of the many small producers the exact production can not be accurately determined.

During the first 7 months of 1914 the price of metallic cadmium ranged from 95 cts. to $1.15 per lb., quotations varying according to quantity and quality. During August and September a few sales were made as high as $1.35 per lb., after which the market relapsed to the previous basis of 95 cts. to $1.15.[1]

[1] *Eng. Min. Jour.*, Jan. 9, 1915.

CEMENT

By Robert W. Lesley

The year 1914 has been a remarkable one in the cement industry. While the curve of prices since the first presentation of figures concerning the industry has shown remarkable variations in prices of natural, Puzzolan and Portland cement, and while the curve of production has likewise shown remarkable variations in each of these products, and while equally remarkable changes have been shown in the curve of exports and imports of Portland cement, the great curve denoting the production of Portland cement in the United States has until the year 1914 been a constantly growing and ascending one. It is this remarkable fact that is to be observed in the year in question. For the first time the production of Portland cement has shown a decrease. The figures of the U. S. Geological Survey comparing the production and shipments of 1913 and 1914 show a falling off of 4.20 per cent. in production and one of 2.54 per cent. in shipments and an increase of 14.92 per cent. in stocks on hand at the close of the year. The figures speak for themselves and may well be considered to show the effect of the European war upon one of the great industries of the United States. Very naturally, in connection with this great falling off in production and shipments, a falling off in prices would be expected, and this is shown in a drop in the average factory price per barrel of $1.005 in 1913 to $0.927 in 1914, or 7.76 per cent. change in the selling price.

Nor is this alone to be noted so far as price is concerned. The close of the year marked a breaking down of the market in the great eastern cement district of the Lehigh and New York state, a gradual sagging away from the established prices which barely yielded cost to the manufacturers, and a sagging away which marked the beginning of a price war in the opening of 1915.

The total production of all kinds of cement in the United States in 1912, 1913 and 1914 is shown in Table I, as found below, and in considering it, it must be remembered that the weight of Portland cement per bbl. is 380 lb. net, Puzzolan 330 lb. and natural 265 lb.

With the lowering of prices for the high-grade Portland cement, it was to be expected that there would be a falling off in the cheaper grades of the Puzzolan and natural cements, and the fact is shown in the figures for the former, while in the latter a very slight increase is shown.

TABLE I.—PRODUCTION OF MARKETED CEMENT IN THE U. S. IN 1912–1914, BY CLASSES

Class.	1912.		1913.		1914.	
	Quantity (Barrels).	Value.	Quantity (Barrels).	Value.	Quantity (Barrels).	Value.
Portland	85,012,556	$69,109,800	88,689,377	$89,106,975	86,437,956	$80,118,475
Natural	821,231	367,222	744,658	345,889	751,285	351,370
Puzzolan	91,864	77,363	107,313	97,663	68,311	63,358
Total	85,925,651	$69,554,385	89,541,348	$89,550,527	87,257,552	$80,533,203

In dealing with the year's figures for Portland cement the Geological Survey has grouped the various plants according to geographical districts and Table II shows the comparative figures for production and shipments for 1913 and 1914, together with comparative figures of average factory prices per bbl.

TABLE II.—PRODUCTION AND SHIPMENTS OF PORTLAND CEMENT
(Figures opposite P relate to production: those opposite S to shipments)

District.		Active Plants.	Production and Shipments (Barrels).			Average Factory Price Per Barrel.		
		1913.	1913.	1914.	Percentage of Change.	1913.	1914.	Percentage of Change.
Lehigh district (New Jersey and eastern Pennsylvania)	P	22	27,139,601	24,614,933	− 9.30	.....	.....	.....
	S	22	26,659,537	23,968,554	−10.09	$0.838	$0.809	− 3.46
New York	P	8	5,208,020	5,886,124	+13.02	.....	.....	.....
	S	8	5,136,334	5,474,191	+ 6.58	0.934	0.917	− 1.82
Ohio and western Pennsylvania	P	9	7,690,010	7,592,065	− 1.27	.....	.....	.....
	S	9	7,287,028	7,466,887	+ 2.47	1.000	0.876	−12.50
Michigan and northeastern Indiana	P	13	5,057,199	5,214,557	+ 3.11	.....	.....	.....
	S	13	4,960,891	5,157,613	+ 3.95	1.030	0.960	− 6.80
Kentucky and southern Indiana	P	3	3,005,417	2,930,735	− 2.48	.....	.....	.....
	S	3	2,861,624	2,932,003	+ 2.46	1.008	0.717	−28.87
Illinois and northwestern Indiana	P	6	12,423,799	11,532,605	− 7.17	.....	.....	.....
	S	6	11,576,938	11,316,645	− 2.25	1.002	0.932	− 6.99
Maryland, Virginia, and West Virginia	P	4	2,668,338	2,784,988	+ 4.37	.....	.....	.....
	S	4	2,529,629	2,793,036	+10.41	0.865	0.877	+ 1.27
Tennessee, Alabama, and Georgia	P	5	3,082,623	2,672,210	−13.31	.....	.....	.....
	S	5	2,958,829	2,577,099	−12.90	0.899	0.935	+ 3.89
Iowa and Missouri	P	8	8,427,012	8,957,613	+ 6.30	.....	.....	.....
	S	8	7,941,620	8,930,465	+12.45	1.074	0.940	−11.45
Great Plains States (Kansas, Oklahoma, and central Texas)	P	15	6,350,646	6,253,731	− 1.53	.....	.....	.....
	S	15	6,190,040	6,016,774	− 2.80	1.063	0.930	−12.51
Rocky Mountain States a (Colorado, Utah, Montana, and western Texas)	P	a8	a2,546,082	2,698,151	+ 5.97	.....	.....	.....
	S	a8	a2,545,473	2,754,591	+ 8.21	a1.319	1.306	− 0.99
Pacific coast States (California and Washington)	P	12	8,498,384	7,092,458	−16.54	.....	.....	.....
	S	12	8,041,434	7,050,098	−12.33	1.461	1.277	−12.66
Total	P	113	92,097,131	88,230,170	− 4.20	.....	.....	.....
	S	113	88,689,377	86,437,956	− 2.54	1.005	0.927	− 7.76

a Includes Arizona in 1913.

Reverting, however, to the old figures as originally shown in the Geological Survey reports by states, Tables III and IV on Production of

Portland cement and shipments of Portland cement speak for themselves.

TABLE III.—PRODUCTION OF PORTLAND CEMENT BY STATES

State.	1913.		1914.		Percentage of Change, 1913.
	Producing Plants.	Quantity (Barrels).	Producing Plants.	Quantity (Barrels).	
Pennsylvania	23	28,701,845	20	26,570,151	− 7.43
Indiana	5	10,872,574	5	9,595,023	−11.74
New York	8	5,208,020	8	5,886,124	+13.02
Illinois	5	5,083,799	5	5,401,605	+ 6.25
California	7	6,159,182	7	5,075,114	−17.60
Missouri	5	4,803,338	5	4,723,906	− 1.65
Michigan	11	4,186,236	11	4,285,345	+ 2.37
Iowa	3	3,623,674	3	4,233,707	+16.83
New Jersey	3	4,460,027	3	3,674,800	−17.61
Kansas	10	3,374,836	9	3,431,142	+ 1.67
Texas	4	2,117,142	4	2,100,341	− 0.79
Washington	5	2,339,202	5	2,017,344	−13.76
Ohio	5	1,667,739	5	1,962,047	+17.65
Utah	3	867,433	3	981,100	+13.10
Other States *a*	16	8,632,084	17	8,291,521	− 3.95
Total	113	92,097,131	110	88,230,170	− 4.20

a Alabama, Arizona, Colorado, Georgia, Kentucky, Maryland, Montana, Oklahoma, Tennessee, Virginia, and West Virginia, with Nebraska additional in 1914.

TABLE IV.—SHIPMENTS OF PORTLAND CEMENT BY STATES

State.	1913.				1914.			
	Shipping Plants.	Quantity (Barrels).	Value.	Average Price per Barrel.	Shipping Plants.	Quantity (Barrels).	Value.	Average Price per Barrel.
Pennsylvania	23	28,060,495	$24,268,800	$0.865	20	25,985,106	$20,944,787	$0.806
Indiana	5	10,219,492	10,218,867	1.000	5	9,540,288	8,342,164	0.874
New York	8	5,136,334	4,801,607	0.935	8	5,474,191	5,020,720	0.917
Illinois	5	4,734,540	4,784,696	1.011	5	5,284,022	4,848,522	0.918
California	7	6,018,262	8,896,734	1.478	7	5,004,633	6,698,905	1.339
Missouri	5	4,485,820	4,556,822	1.016	5	4,706,389	4,485,744	0.953
Iowa	3	3,455,800	3,972,876	1.150	3	4,224,076	4,008,915	0.949
Michigan	11	4,081,281	4,228,879	1.036	11	4,218,429	4,064,781	0.964
New Jersey	3	4,255,015	3,638,755	0.855	3	3,530,476	3,081,205	0.873
Kansas	10	3,291,818	3,286,861	0.998	10	3,237,906	2,643,415	0.816
Texas	4	2,108,737	2,663,063	1.263	4	2,096,140	2,686,653	1.282
Washington	5	2,023,172	2,853,260	1.410	5	2,045,465	2,303,433	1.126
Ohio	5	1,631,055	1,721,423	1.055	5	1,919,859	1,913,797	0.997
Utah	3	950,469	1,233,421	1.298	3	974,723	1,317,575	1.352
Other States *a*	16	8,237,087	7,980,911	0.969	17	8,196,253	7,757,859	0.947
Total	113	88,689,377	$89,106,975	1.005	111	86,437,956	$80,118,475	0.927

a Alabama, Arizona, Colorado, Georgia, Kentucky, Maryland, Montana, Oklahoma, Tennessee, Virginia, and West Virginia, with Nebraska additional in 1914.

A large part of the advance in the average price of 1913 over 1912 is shown to have been completely wiped out, and the indication of rational conditions beginning to prevail in the industry so far as prices are concerned was practically obliterated by the figures prevailing at the end of the year 1914 and forming the basis of 1915 quotations.

An examination of the table showing the average factory price per barrel for 1914 indicates that the largest loss was in the Southern Indiana

and Kentucky districts, and that there it was 28.87 per cent., that there was a loss of around 12 per cent. in the Pacific Coast district, the Nebraska, Kansas and Central Texas and the Ohio and Western Pennsylvania districts, while the loss in the Lehigh district of eastern Pennsylvania and New Jersey was only 3.46 per cent. This loss occurred practically during the closing months of the year and has been accentuated materially since the opening of the present cement season. In dealing with these figures of price, it must be recollected that the district in question produced over 30 per cent. of the total output for the year and that the shrinkage in price upon such a large number of barrels operated materially to influence the total drop in price on the year's production.

According to the Geological Survey, "an analysis of the general comments on prices shows that 65 per cent. of the mills received a lower average price for Portland cement during the year 1914 than in the preceding year, at 23 per cent. of the mills practically the same price prevailed and 12 per cent. of the manufacturers reported having received higher prices. The low prices in certain districts have been ascribed in part to over-production."

By reference to Table II and Tables III and IV it will be again noted that the preponderance of the Lehigh district in the industry is gradually becoming a thing of the past. In the early days representing 90 per cent. of the total production and for many years constant at about 50 per cent., this year's output was only 24,614,933 bbl., or barely 28 per cent. of the country's production, as against 30 per cent., which were the 1913 figures, the production falling off very nearly 10 per cent. during the year.

The marked increase in the production of the New York district may be again attributed to the Erie Canal, the Water Board and the New York Subway work, and to the road building going on in that state. The increase which was shown in 1913 in the Illinois and Northwestern Indiana district was not apparent in 1914, the output showing only a slight increase, while California and the Pacific Coast district fell off about 12 per cent.

In the annual address of Richard L. Humphrey, the President of the American Concrete Institute, the 1914 figures on Portland cement are commented on and the prediction is made that the set-back is but temporary and that at the end of the present acute business depression, the production curve will start upward at a slope that will soon place it even with the mark that it would have reached had the business of the last few years been normal. This prediction is based upon a thorough knowledge by the speaker of the enormously increasing demand for Portland cement in every form of construction, and when to this greatly increased demand of our own country is added what is certain to be a future demand,

namely, that of the great continent to the south of us, the predictions may have solid basis for their realizations.

The Balkan war, which was the first to tighten European credits and to affect the purchasing power of the South American countries, was markedly supplemented in that region by the great war now raging in Europe, and South America as well as North America found its purchasing power materially reduced, owing to the great advance in the rates for capital and the lessened ability to secure capital for building improvements. In our own country the outbreak of the European war was signalized by the withdrawal of capital from almost all of its ordinary employments and the building industry was the first to suffer. Building statistics show a marked falling-off and it can be readily understood that the erection of large hotels, office buildings, warehouses, apartment houses and other similar structures could not profitably be done with money ranging from 8 to 10 per cent., when the completed buildings were expected to compete in service and rental with other similar edifices erected with 4 and 5 per cent. money.

These conditions materially affected the output of cement all over the world in the latter months of 1914 and it was only toward the end of that year that there came some slight demand for peremptory needs in the lands to the south of us. This demand, however, is a continuing one in the territory mentioned, and it is expected that a large market for American Portland cement will be found, especially so now that American capital and American bankers are establishing themselves in South American countries.

TABLE V.—AVERAGE PRICE PER BARREL OF PORTLAND CEMENT, 1870–1914

1870–1880	$3.00	1893	$1.91	1904	$0.88
1881	2.50	1894	1.73	1905	0.94
1882	2.01	1895	1.60	1906	1.13
1883	2.15	1896	1.57	1907	1.11
1884	2.10	1897	1.61	1908	0.85
1885–1888	1.95	1898	1.62	1909	0.813
1889	1.67	1899	1.43	1910	0.891
1890	2.09	1900	1.09	1911	0.844
1891	2.13	1901	0.99	1912	0.813
1892	2.11	1902	1.21	1913	1.005
		1903	1.24	1914	0.927

In view of the fact that the principal companies are scattering their works at various distributing points in the country in order to get the cement to the consumer at the lowest cost per barrel for freight, it is interesting as a side-light upon this important question to note that the distribution of the works is not only one of freight advantage and local markets, but is also one of the assembling of the raw materials and the fuel needed in the burning and grinding operations. Tables VI and VII bear upon these important subjects.

TABLE VI.—STATISTICS SHOWING FUEL USED IN BURNING PORTLAND CEMENT

Fuel.	1913.				1914.			
	Number of Plants.	Number of Kilns.	Barrels.	Percentage of Total.	Number of Plants.	Number of Kilns.	Barrels.	Percentage of Total.
Coal	88	695	78,508,891	85.2	88	669	72,471,772	82.1
Coal and oil	.....	.....	.....	.....	1	24	4,183,842	4.7
Coal, oil, and gas	.....	.....	.....	.....	1	5	712,314	0.8
Coal and gas	.....	.....	.....	.....	2	14	1,564,113	1.8
Oil	18	119	10,013,206	10.9	14	107	7,698,720	8.7
Oil and gas	.....	.....	.....	.....	2	15	1,292,578	1.5
Producer gas	.....	.....	.....	.....	1	1	65,420	0.1
Natural gas	7	59	3,575,034	3.9	1	4	241,411	0.3
Total	113	873	92,097,131	100.0	110	839	88,230,170	100.0

In Table VII the materials used are shown:

TABLE VII.—PRODUCTION, IN BARRELS, AND PERCENTAGE OF TOTAL OUTPUT OF PORTLAND CEMENT IN THE U. S. ACCORDING TO TYPE OF MATERIAL USED, 1898–1914

Year.	Type 1. Cement Rock and Pure Limestone.		Type 2. Limestone and Clay or Shale.		Type 3. Marl and Clay.		Type 4. Blast-furnace Slag and Limestone.	
	Quantity.	Percentage.	Quantity.	Percentage.	Quantity.	Percentage.	Quantity.	Percentage.
1899	4,010,132	70.9	546,200	9.7	1,095,934	19.4	.....	.....
1900	5,960,739	70.3	1,034,041	12.2	1,454,797	17.1	32,443	0.4
1901	8,503,500	66.9	2,042,209	16.1	2,001,200	15.7	164,316	1.3
1902	10,953,178	63.6	3,738,303	21.7	2,220,453	12.9	318,710	1.8
1903	12,493,694	55.9	6,333,403	28.3	3,052,946	13.7	462,930	2.1
1904	15,173,391	57.2	7,526,323	28.4	3,332,873	12.6	473,294	1.8
1905	18,454,902	52.4	11,172,389	31.7	3,884,178	11.0	1,735,343	4.9
1906	23,896,951	51.4	16,532,212	35.6	3,958,201	8.5	2,076,000	4.5
1907	25,859,095	53.0	17,190,697	35.2	3,606,598	7.4	2,129,000	4.4
1908	20,678,693	40.6	23,047,707	45.0	2,811,212	5.5	4,535,300	8.9
1909	24,274,047	37.3	32,219,365	49.6	2,711,219	4.2	5,786,800	8.9
1910	26,520,911	34.6	39,720,320	51.9	3,307,220	4.3	7,001,500	9.2
1911	26,812,129	34.1	40,665,332	51.8	3,314,176	4.2	7,737,000	9.9
1912	24,712,780	30.0	44,607,776	54.1	2,467,368	3.0	10,650,172	12.9
1913	29,333,490	31.8	47,831,863	51.9	3,734,778	4.1	11,197,800	12.2
1914	24,907,047	28.2	50,168,813	56.9	4,038,310	4.6	9,116,000	10.3

Exports and Imports.—The imports of cement, as the table below shows, have been continually diminishing, but the year 1914 shows a slight increase over the preceding 2 years.

TABLE VIII.—IMPORTS OF FOREIGN CEMENT, 1878–1914, IN BARRELS OF 380 LB.

1880	187,000	1892	2,440,654	1904	968,409
1881	221,000	1893	2,674,149	1905	896,845
1882	370,406	1894	2,638,107	1906	2,273,493
1883	456,418	1895	2,997,395	1907	2,033,438
1884	585,768	1896	2,989,597	1908	842,121
1885	554,396	1897	2,090,924	1909	443,888
1886	915,255	1898	1,152,861	1910	306,863
1887	1,514,095	1899	2,108,388	1911	164,670
1888	1,835,504	1900	2,386,683	1912	68,503
1889	1,740,356	1901	939,330	1913	84,630
1890	1,940,186	1902	1,963,023	1914	120,906
1891	2,988,313	1903	2,251,969		

While the exports of cement seem to have passed their high point in the year 1912 and still show a falling off in the year 1914 by reason of the completion of the Panama Canal, these figures are for the future likely to be increasing ones and to have the greatest effect upon the output of the Lehigh, New York, and other districts along the Atlantic Coast.

TABLE IX.—EXPORTS OF CEMENT, 1900-1914, IN BARRELS

Year.	Quantity.	Value.	Percentage of Total.	Year.	Quantity.	Value.	Percentage of Total.
1901.....	373,934	$679,296	1.9	1908.....	846,528	$1,249,229	1.6
1902.....	340,821	526,471	1.3	1909.....	1,056,922	1,417,534	1.6
1903.....	285,463	433,984	0.95	1910.....	2,475,957	3,477,981	3.2
1904.....	774,940	1,104,086	2.4	1911.....	3,135,409	4,632,215	3.9
1905.....	897,686	1,387,906	2.2	1912.....	4,215,532	6,160,341	5.1
1906.....	583,299	944,886	1.1	1913.....	2,964,358	4,270,666	3.2
1907.....	900,550	1,450,841	1.7	1914.....	2,140,197	3,088,809	2.4

THE WORLD'S MARKETS

Belgium.—Belgium has held her own, though a large part of the cement produced in Belgium is not of the class known as the true Portland cement, but is of the natural Portland cement produced by calcining argillaceous limestone together and grinding the resultant mass into powder. In referring to the industry in this country a correspondent of the London *Times* writing in January, 1914, says:

"It is stated that plans are still being considered for erecting three new cement works in the neighborhood of Zeebrugge, Huy, and Maestricht, respectively, for the manufacture of Portland cement. If carried out these schemes will bring the number of cement works existing in Belgium for the manufacture of this special class of cement to a total of 20."

It will be noted that the three locations mentioned are in the heart of the war zone and are occupied by soldiers of the various nations engaged.

Canada.—The Canadian figures as given by the Mineral Products of Canada are as follows, the year showing a marked falling off, as compared with 1913:

The total quantity of Portland cement, including slag cement and natural Portland made in 1914, was 8,727,269 bbl. of 350 net lb. each, as compared with 8,886,333 bbl. made in 1913, a decrease of 159,064 bbl., or about 2 per cent.

The total quantity of Canadian Portland cement sold or used during 1914 was 7,172,480 bbl., valued at $9,187,924, or an average of $1.28 per bbl., as compared with 8,658,805 bbl., valued at $11,019,418, or an average of $1.27 per bbl. in 1913, showing a decrease of 1,486,325 bbl., or 17 per cent.

The total imports of cement in 1914 were 343,076 cwt., equivalent to 98,022 bbl. of 350 lb., valued at $147,158, or an average of $1.50 per bbl., as compared with imports of 254,093 bbl., valued at $409,303, or an average of $1.61 in 1913.

The total consumption of cement therefore, neglecting a small export, was 7,270,502 bbl., as compared with a consumption of 8,912,898 bbl. in 1913, a decrease of 1,642,396 bbl., or 18.4 per cent.

China.—The government of Canton having by special ruling forbidden the export of cement rock and cement-making material, the Green Island Cement Works of Hong Kong, one of the largest in China, is suffering severely and has been almost put out of that territory. This works did a large trade with the Philippines. It has to a considerable extent been superseded in the market of that territory by the Hai Fong works located in Indo-China, which has a capacity of between 250,000 and 300,000 bbl. and which shipped in a single year nearly 120,000 bbl. to the Philippines alone.

Cuba.—In Cuba the principal imports are from the United States, as a preferential duty prevails in favor of this country. The Almendares Works near Havana has been in existence for many years and produces several hundred thousand barrels of cement a year.

Denmark.—Denmark of late years has been a growing producer.

England.—Of the European countries England comes next with the production of about 17,000,000 bbl., an increase over the previous year. While English cement works have been going on, despite the war, manufacturing operations have suffered severely by the war conditions existing in the North Sea. The coal consumed by the English works on the Thames and Medway comes from the north, and many of the vessels have been lost or sunk by submarines and freight rates have advanced and freight room has become very scarce.

France.—The production of Portland cement in France remains stationary at about 7,000,000 bbl.

Germany.—As usual, Germany is seen to be the largest producer of Portland cement next to the United States. According to the figures of the German Association of Portland Cement Manufacturers, which represents 98 factories in that country, the total production for the year 1914 was 42,050,000 bbl., an increase of 1,650,000 bbl. over 1913.

India.—In India two cement works are projected; one in the Punjab which is to be operated under broad franchises granted by the government of that province, and which is to have an output of about 100,000 bbl. a year; and the second to be located at Katni in the central province of India by the Katni Cement & Industrial Co. This latter plant is to have an output of about 200,000 bbl., while still a third plant is under

construction for interests connected with the Associated Portland Cement Manufacturers of London.

Japan.—Reports from Japan are to the effect that there has been a material slackening up in the output of cement, and that many of the smaller works are suffering from lessening demand.

Mexico.—War conditions have interfered materially with the production in Mexico where two or three works have existed for a long time. The Hidalgo Works near Monterey have been in the center of the war district, as have also the works to the south in the vicinity of Mexico City.

South America.—Brazil imported in the year 1913 about two and a half million barrels of cement, of which Germany was the largest shipper, and the United States contributed only about 40,000 bbl. Brazil had for many years a cement plant at Sao Paolo, built by French capital, and is talking of the construction of additional works.

Chile consumed about 930,000 bbl. in 1913, about 100,000 bbl. of which was manufactured in two small plants at Calera, the balance having been imported.

Uruguay and the Argentine both were large importers of cement, and recent figures show that Germany and Belgium were among the largest shippers, while the American sales which began a few years ago are increasing slowly.

CHROMIUM

The only commercially important ore of chromium is chromite. This ore is found widely distributed in various parts of the United States, particularly in Massachusetts, Pennsylvania, Maryland, North Carolina, Wyoming and California. Almost the entire production of chromite since 1880 has come from California. Small quantities have been mined from time to time in Wyoming. The following table gives the production of chrome ores in the United States since 1900:

Year.	Quantity, (Long Tons).	Value.
1900	140	$1,400
1901	368	5,790
1902	315	4,567
1903	150	2,250
1904	123	1,845
1905	22	375
1906	107	1,800
1907	290	5,640
1908	359	7,230
1909	598	8,300
1910	205	2,729
1911	120	1,629
1912	201	2,753
1913	255	2,854
1914	591	8,715

The largest production of chromic iron ore ever recorded in the United States was in 1894, when the output reached 3680 long tons, valued at $53,231; the highest value was attained in 1883, when an output of 3000 tons had a value of $60,000.

There is no import duty on chromic iron ore, and its occurrence near the sea in foreign countries enables it to be imported and sold along our eastern coast at low rates. Chromite is usually sold on the basis of 50 per cent. content of chromic oxide. It was quoted for carload lots ex ship in New York during 1912 at $14 to $16 a ton, although the price of imported chromite for the year averaged only $9.27 a long ton. The average value of the chromite imported during the fiscal year ending June 30, 1913, was $10.12, apparently an increase of 10 per cent. over that of 1912 in the average price of the material imported. Nevertheless, the market price quoted for imported chromite in lump form in carload lots at the Atlantic seaboard was $14 a net ton.

The price of ore on the Pacific coast has apparently been declining since 1901, but the difference may be due to the grade of the ore. In 1911 it was $13.58 a long ton and in 1912 the average was $13.70, although

some of the richer ore sold for $17. In 1913 the average price of the ore sold declined to $11.19. On account of the long railroad haul the California chromic iron ore can not compete in the Atlantic States with the cheaply delivered foreign ore.

The price of the chromate and bichromate of potash imported in 1912 averaged 9 cts. a pound and that of the chromic acid 15¾ cts. a pound. In January, 1914, American manufacturers quoted bichromate of potash at 6¾ to 7¾ cts. a pound and bichromate of soda at 4¾ to 5 cts. a pound f.o.b. at the seller's works.

The market price of chrome brick, standard sizes, in carload lots, January 1, 1914, was, at the Atlantic seaboard, $135 a thousand; at Pittsburgh, $145 a thousand.[1]

The importations of chrome ore, chromic acid, and chromate of potash are given in the following table:

CHROMATE AND BICHROMATE OF POTASH, CHROMIC ACID, AND CHROME ORE IMPORTED AND ENTERED FOR CONSUMPTION IN THE UNITED STATES, 1908 TO 1914, INCLUSIVE (a)

Year.	Chromate and Bichromate of Potash.		Chromic Acid.		Chrome Ore.		Total Value.
	Quantity.	Value.	Quantity.	Value.	Quantity.	Value.	
	Pounds.		Pounds.		Long Tons.		
1908	216,081	$15,453	3,805	$708	27,876	$345,960	$362,121
1909	537,017	28,837	7,559	1,412	39,624	460,758	491,007
1910	406,790	19,569	9,850	1,635	38,579	415,768	436,972
1911	22,408	2,159	6,789	1,349	37,540	407,958	411,466
1912	32,913	3,085	8,728	1,376	53,929	499,818	504,279
1913	18,629	1,819	5,562	1,100	65,180	622,821	625,740
1914	31,858	2,375	9,164	1,597	74,686	655,306	659,278

(a) Bureau of Foreign and Domestic Commerce.

The quantity and value of imports of chrome yellow or green are given in the following table:

Year.	Quantity, Pounds.	Value.
1909	109,494	$19,492
1910	170,073	23,107
1911	156,586	25,029
1912	156,733	25,516
1913	161,153	24,731

The uses of chrome ores are: in the manufacture of ferro-chromium, employed for making special steels, alone or in combination with nickel, manganese, or tungsten; for lining furnaces where the corrosive action is very great; and in the manufacture of chromium compounds for use in production of pigments, dyes, mordants and tannages.

The principal sources of chrome ore in foreign countries are given in the following table:

[1] *Min. Res. of U. S.*, 1913.

THE PRINCIPAL SUPPLIES OF CHROME ORE (a)
(In metric tons)

	1904.	1905.	1906.	1907.	1908.	1909.	1910.	1911.	1912.	1913.	1914.
Bosnia	279	186	320	310	500	332	320	250	200	305	.....
Canada	5,512	7,781	7,936	6,528	6,554	2,470	279	143	.....	.....	123
Greece	15,430	8,900	11,530	11,730	4,350	9,600	9,463	4,615	6,468	6,930	.....
India	3,654	2,751	4,445	18,597	4,821	9,398	1,765	3,864	2,936	4,908	.....
Japan	.....	.....	.....	.....	.....	.....	2,091	1,500	.....	.....	.....
New Caledonia (b)	42,197	51,374	57,367	25,371	46,890	40,000	40,000	82,806	51,516	63,370	.....
New South Wales	403	53	15	30	*Nil.*	*Nil.*	*Nil.*	150	23	*Nil.*	.....
Rhodesia	....	....	3,308	7,273	12,118	37,024	40,000	47,600	62,850	63,384	.....
Russia	26,575	27,051	16,969	25,528	10,950	22,213	(c)	(c)	21,277	.....	.....
Turkey	.....	.....	.....	21,111	28,394	11,364	.....	.....	.....	.....	.....
United States	125	22	109	294	364	606	208	122	204	259	601

(a) From the official reports of the respective countries. No complete statistics are available for Turkey or Africa. (b) Exports, except 1909 and 1910. (c) Statistics not yet available.

Deposits of chromic iron ore occur in Maryland and the adjacent portion of Pennsylvania, in North Carolina, and in Wyoming, but the only deposits operated in the United States within recent years are those in California. Numerous deposits have been reported in 32 counties of that state, according to the United States Geological Survey, and many of them could be worked if the demand for the ore and its value warranted exploitation. The available deposits, with much in reserve, largely exceed the local demand for refractory material in a field extending as far east as the Rocky Mountains.

The production of chromic iron ore in the eastern portion of the United States, where the demand is greatest, ceased years ago. The supply is now obtained wholly by importation, mainly from South Africa. On the other hand, the Pacific coast supplies all its own demands by home production. Possibly with the completion of the Panama Canal the California product will also invade eastern markets.

Chrome ore was first mined in California about 1880. The earliest discoveries were in Del Norte, Alameda, and San Luis Obispo Counties. The mines of these and other counties yielded 2000 or 3000 tons per year until about 1895 or 1896, much of the ore being shipped to the Atlantic seaboard and to Europe. Removal of the protective tariff and competition of newly discovered deposits in other countries resulted in the complete closing of the California mines for several years. Operations were resumed in 1900, but it was not until the past 2 or 3 years that production has been more than 200 or 300 tons per year. On the whole, the future of California chromite is brighter to-day than it has been for several years.[1]

Just what effect the European war is likely to exert on the California chrome industry is not quite apparent. The countries producing the largest quantities of ore are among the possessions of England, while

[1] Chromite Possibilities in California, S. H. Dolbear, *Min. Press*, Mar. 6, 1915.

France is the largest producer of ferro-chrome alloys. No records are kept of ferro-chrome importations, so that the extent of our dependence upon Europe for this commodity is not known. Chromium alloys are manufactured in the United States at Niagara Falls. It may be a significant fact that months before the European trouble broke out, American manufacturers of chrome compounds had manifested a keen interest in the chrome fields of California and representatives visited the state, investigating the possibility of purchasing ore at this point. Another hopeful phase of the present situation is that those who are investigating the local field with a view toward the manufacture of manganese alloys are also considering the possibility of a local ferro-chrome production. Furthermore, American brokers have made inquiries in California during the past 2 years for large tonnages for delivery in both Europe and America.

Brown Mine.—This mine is about 2 miles south of Dunsmuir in Shasta County, near the Siskiyou County line. From a transportation point of view, its situation is fortunate, being but approximately 1 mile from the Southern Pacific railroad. Chrome ore has been known at this point for many years. As early as 1885 the manufacture of chromic salts was considered in connection with deposits at this place. The mine is now equipped with a gravity tram about 1600 ft. long, which brings the ore down to a good wagon road leading to the point of shipment. The chromic oxide content ranges from 45 to 55 per cent. About 2500 tons had been produced from this mine up to January 1, 1915. During the past year, L. H. Brown, who has been engaged in the production of chrome ore since 1906, mined 867 tons, of which 567 was sold and shipped. Three hundred tons has been stored at railroad for future orders. The prospect seems good here for further production, the ore occurring in elongated lenses as wide as 25 ft. A series of these lenses has been traced for several hundred feet.

Lesco Mine.—Nine claims constitute this property, each of which covers separate lenses of chrome ore. The mines are 9 miles nearly due north of Piedra, a terminal point of a Santa Fe railway branch line in Fresno County. The road connecting the mine with Piedra, however, is over 20 miles long, and a portion of it can not be traversed by wagons during the winter months. A railroad is projected which, if built, would terminate within 8 miles of the property, and would be brought within 4 miles if there could be developed a sufficient tonnage. In the meantime, Clovis, a point on the Southern Pacific railroad, about 12 miles distant, is more accessible than Piedra. The first ore taken from these claims was hauled to the nearby Copper King mine for use in its smelter. Forty or 50 tons was hauled from the Mary Collins claim to the Fresno

Copper Co.'s smelter near Academy. The principal development work on this property is on the Mary Collins and Blanche H. claims. On the Mary Collins mine a block about 12 ft. deep, 6 ft. wide, and containing about 60 tons of hard clean ore has been exposed. About 30 tons is also on the dump. Samples gave the following analysis:

	Per Cent.
Chromic oxide	43.21
Silica	6.40
Ferric oxide	7.40
Aluminium oxide	33.80
Magnesium oxide	2.40

With the exception of shipments hauled by wagon to local smelters, all ore shipped from here passed through Piedra. The mine has not been operated since 1913, when about 60 tons was shipped.

On the Blanche H. mine, only small segregated lenses have been exposed. The claim is locally known as the "Potato Patch," owing to the fact that hard pieces of ore are found in the soil. These broken pieces of ore frequently weigh several pounds, and are recovered by screening the soil. They occur over 10 or 15 acres, the depth of the soil not being shown by the present workings. This is undoubtedly due to the comparatively rapid weathering of the surrounding country rock and the attendant liberat on of lenses of ore. A sample of this ore gave the following analysis:

	Per Cent.
Chromic oxide	43.72
Silica	11.70
Ferric oxide	4.30
Aluminium oxide	32.40
Magnesium oxide	1.10

In all of the samples taken from this section the aluminium oxide content is relatively high, a condition which is said to make it particularly adaptable to the manufacture of chrome brick.

Cedar Mountain Mine.—Several thousand tons has been shipped from these deposits, which are situated about 14 miles southeast of Livermore in Alameda County. The deposit is about 1 mile from the Swindell Magnesite Co.'s mine. Of late years but a few tons has been shipped from here, and most of this was taken from ore left on the dump at the time of closing down the mine. Some of the old workings are still open to a depth of 30 ft., and the drift faces show some ore. About 1 mile distant, in Devil's Hole, another deposit is said to exist, but this is almost inaccessible and nothing is known of its extent.

Miscellaneous Occurrences.—Aside from those mentioned in the foregoing paragraphs, there has been little activity in the many deposits of California during the past year or two. A little development was done in some of the old workings near Santa Maria, San Luis Obispo County, in 1913, but this is understood to have revealed little of interest. Two new deposits of fairly high-grade ore have been lately discovered in San

Bernardino County. One of these is situated about 18 miles west of Hesperia, a station on the Santa Fe main line, about half way between Cajon pass and Victorville. The other is 10 miles farther on in the same direction and is at present not accessible for lack of roads. Analyses of the ore from these deposits made for Alexander Gray showed 45 to 68 per cent. Cr_2O_3. An interesting feature of these ores is that they are said to contain $1.20 per ton in gold and 4 oz. silver. As one of the reasons for believing that chrome ore is a segregation from the magma is the absence of pneumalytic minerals, the study of this deposit should be of particular interest from a geological point of view.

A deposit of high-grade ore, averaging 60 per cent. chromic oxide, is reported 20 miles from Coalinga in Fresno County. The mine is accessible by good roads. In 1913 there was a production of 900 tons reported from Calaveras County. The source of this ore is shrouded in mystery, and the brokers handling the output decline to disclose the identity of the mine. It was recently stated that while the rail shipment originated in Calaveras County, the ore was mined in an adjoining county. Chromite is known to occur at several points in this and the five adjoining counties, Amador, Alpine, Tuolumne, Stanislaus, and San Joaquin. In Calaveras County it has been mined in Sec. 20, T. 4 N., R. 11 E. by the Penn Chemical Co. for use in its reverberatory furnaces at Campo Seco. It is also found sparingly at various points in the vicinity of Milton and at Big Trees.

The counties in California contributing chiefly to the production of chromic iron ore in the past are Shasta, San Luis Obispo, Fresno, Alameda, Del Norte, Tehama, Glenn, Placer, Calaveras, Siskiyou, Napa, and Sonoma.

Canada.—Chromite is found in the Eastern Townships of the Province of Quebec, in the neighborhood of Coleraine, Thetford Mines, and Black Lake. It exists as irregular pockets and masses, streaks and disseminated mineral in Cambrian serpentines.

Several mines and mills have been operated in the district, which for years turned out a considerable quantity both of lump ore and concentrates. The average tenor of shipments varied between 45 and 55 per cent. chromic oxide, and mineral as high as 58 per cent. has been obtained. For some time Canada and Asia Minor practically supplied all American needs, but the competition of the New Caledonia and Portuguese deposits proved too strong, and in 1910 the Canadian mines ceased operations.

Only a comparatively small portion of the chromite-bearing area has been actively explored, and through this mining operations have been confined to open cuts and other shallow workings. The probability is that the region contains one of the largest developments of chromite

known, and with the employment of more systematic and intensive operating methods it should take a leading position among the world's producers of the mineral.[1]

Representative samples of Canadian chromites yielded the following results:

	Cr_2O_3	Al_2O_3	SiO_2	MgO	FeO	CaO	Total.
No. 1	51.03	12.16	5.22	16.32	13.06	2.61	100.0
No. 2	53.07	8.01	6.44	16.08	15.27	1.20	100.7
No. 3	55.06	.....	1.60	.....	21.70	....	.....
No. 4	65.16	7.48	....	.....	27.36	....	100.0
No. 5	49.75	11.30	....	18.13	21.28	....	100.4

The Canadian production in 1914 amounted to 123 short tons. Several years ago the production amounted to several thousand tons, but for the last 5 years the production has been only nominal.

Greece.—The exports of chrome ore from Thessaly continue to show a steady, if small, increase. The figures for the past 3 years are as follows: (1911) 3200 tons; (1912) 4870 tons; (1913) 5300 tons.[2] The official reports of production over the same period were as follows: (1911) 4615; (1912) 6498; (1913) 6930 metric tons.

Exports for 1914 are reported as 8155 tons, valued at $73,061.

Rhodesia.—The deposits at Selukwe are worked by the Rhodesia Chromite Mines, Limited, a company belonging to the Bechuanaland Exploration Co. The chrome mine has been a producer since 1907 and in 1913 the output was 63,384 tons, valued at £141,481. The value of the crude ore shipped from Beira works out at about £3 5s. per ton, but as from this there has to be deducted mining charges and a £1 per ton railway rate between Selukwe and Beira, the margin of profit is small. The chromite is found in a talc-schist and serpentine rock, which forms an irregular narrow body widening at its northern end where the mine and the town of Selukwe are situated. The rock has intruded on the older formation to the east, which is composed of banded ironstone and conglomerate belonging to pre-Cambrian age, and in its turn has been invaded by the Mont D'Or granite. Ultra-acid granite intrusions are found in the wider part of the talc-schist rock and form the prominent hills of the neighborhood. The constituent rocks of the talc-schist and serpentine group present a great variety; they are chiefly talcose, carbonate or dolomitic, and chlorite schists, and serpentines are present only in small amount. The main types are gray and buff talc-schists, speckled talc-carbonate schist, red talcose and green chloritic schists, pale and dark green serpentines, and a quartz-chromite rock considered to be a silicified serpentine. The talc-carbonate schist and silicified serpentine are resistant to eroding agencies, the former giving rise to sharp crags at Block Rock and the latter to rounded hills, as at Chrome Hill and Selukwe

[1] *Min. Jour.*, Apr. 10, 1915.
[2] *Min. Jour.*, Jan. 16, 1915.

Peak. The serpentines appear to be chiefly metamorphosed peridotite. The silicified serpentines consist of massive chert, and are of green color derived from chromium. In some places they have a schistose structure. Chromite is always present, and usually hematite and chlorite. Chromite is distributed throughout the talc-schists and serpentines in disseminated crystals and grains, but at certain places, notably in the talc-schist, talc-carbonate schist, and silicified serpentine, it occurs massive in the form of lenses. At the mines at Chrome Hill, the chromite is in whitish speckled talc-schist, which is not always pronouncedly schistose and usually fairly siliceous, and also in ferruginous silicified serpentine. As a rule the chromite bodies are situated near the margin or on the actual edge of the talc-schist-serpentine formation, and occasionally they pass into the adjacent formations. Over 130 lenses have been mapped on the surface at various points, ranging from 150 to 450 ft. in length. Ten are at the Chrome mine, partly merging into each other and being easily attacked by ordinary quarrying methods.[1]

[1] *Min. Mag.*, Feb., 1915.

711533

COAL AND COKE

By A. T. Shurick[1]

While the year 1914 opened under moderately auspicious conditions, this soon gave way to a disappointing dullness, and the last half found the commercial world grappling with the most tremendous demoralization in history. Coming as a distinct surprise, the shock could not have been more severe. Our threatened entanglement in Mexico, the Colorado strike with its accompanying spectacular demonstrations extending from coast to coast, and the failure of several powerful banking and commercial institutions, were all dwarfed into insignificance.

But that we still have much cause for self-congratulation, even in the midst of all this disarray, is an important compensation for us. Our losses, sacrifices and sufferings have been insignificant as compared with Europe; and while these warring states are steadily weakening, the potential strength of this country is increasing in a like proportion so that we may ultimately occupy a position in the world's business and commercial affairs perhaps never dreamed of.

One of the most impelling constructive developments of the year was the general abatement in destructive legislation, so inimical to the industrial progress of the country. Popular disapproval of these policies was evident in the November election, the defeat of Governor Cox of Ohio forming an example in which the coal industry is more particularly interested, and politicians must soon awake to a realization that such policies can not be considered as a passport to public favor.

As compared with the previous year, 1914 was generally unsatisfactory in every respect, and a period of pronounced discouragement to both operators and sales agents. Even in the face of a possible suspension at the mines the market began to develop soft spots as early as March which were followed by a persistent and extreme dullness throughout the year. By the middle of summer the selling agents were reporting the situation as one of the dullest in their recollection, and strict curtailment propagandas were put into effect, which for a time gave encouraging hopes of rectifying the trouble. Producers also placed a favorable interpretation upon the European war at first, seeing indications for an immediate expansion of our export business on a tremendous scale, with the result that extra supplies were ordered and sales agents showed a marked hesitancy to commit themselves on future negotiations. For a brief

[1] Abstracted from *Coal Age*, Jan. 9, 1915, p. 62.

time there was a sharp flurry in export business, but through it all consumers showed every confidence in being able to obtain adequate supplies and when the fallacy of expecting any important relief in this direction was finally and definitely disposed of, hopes of any improvement were abandoned by even the most optimistic. The placing of the New Haven contract, involving a quarter of a million tons, with Cape Breton interests for shipments in English vessels further accentuated the depression in the New England district.

One of the first developments immediately following the various declarations of war was the establishment of moratoria on the part of nearly all the involved states. Perhaps the most amazing feature of this was the disposition on the part of the European countries to shift the blame for this demoralization onto the United States—a responsibility which, strange to say, appears to have been generally accepted in this country. The statement was repeatedly made that we were unable to meet our maturing obligations when, as a matter of fact, it was the Europeans themselves who suspended payment of all indebtedness, a condition which was not at any time considered in this country.

The effects of these moratoria in this country were, of course, enormous, particularly as regards England. As is well known, London is the chief clearing house of the world; not only was she responsible for her own indebtedness to us, but practically all of our foreign and export business the world over is cleared through the London banks. The British moratorium, originally declared for 30 days only, ran over a period of 3 months before it was finally lifted, and during this time it is estimated that our exports, for which payment was held up in London, aggregated nearly half a billion dollars.

Certainly the first shock of the war was succeeded by a wonderfully effective constructive propaganda. Exchange, commerce and credit, problems requiring immediate solution, were hastily patched up with temporary expedients and later re-established on a permanent basis. Restrictions were slowly removed, the exchanges gradually getting under way during the last month, and investment and speculation resumed, though on a much reduced scale. There is a growing conviction among conservative observers that, with the bottom of the depression now past, the recovery should continue even though the war still exists.

American operators anticipated such unlimited possibilities in the export trade when the European war was precipitated that they even went so far as to be conservative about future commitments, in spite of the fact that they were facing one of the most depressed markets in the history of the trade. Prices stiffened up perceptibly, and there were well-defined rumors of moderate premiums offered in the offshore trade.

Indeed, a substantial increase might have been experienced in the export business, had it not been that all German and Austrian shipping was abruptly interned, while the English government was reported to have chartered 1500 steamers, with the result that there was a runaway market in ocean freights, the situation finally culminating with rates entirely prohibitive for coal shipping. The difficulty in making proper financial arrangements also accentuated the trouble, South American merchants demanding credit extending over 2 to 4 months, and frequently asking renewals at the end of that period.

One of the significant developments in this trade during the year was the completion of two of the largest coal piers in the world at Hampton Roads, which will add materially to our exporting capacity. It is also interesting to note that the government has undertaken to facilitate this branch of our foreign business by directing the efforts of the government's technical staffs to the assistance of American coal exporters.

On the whole, the year has been a most important one for American coal exporters for the reason that it has taught them much regarding the foreign markets, the competitive coals and the methods under which they will be expected to do business. When war was first declared there was a rush of American sales agents to the Southern markets in unprecedented numbers, and, although their reports on the situation were more or less uniformly discouraging, they have gained a knowledge and insight into existing conditions which will be invaluable in the years to come. It is clear to all that American exporters could have materially increased their tonnage had they been willing to meet certain conditions as to credits, etc.

A period of depression such as has characterized the country during the past 12 months inevitably works to the discomfiture of the labor unions. Such has been the case during the past year to even more than the usual extent, and this in spite of the fact that the National administration has shown a pronounced sympathy with the labor parties and has exerted its best efforts to assist them in every way.

By far the most important development in the labor history of the country for the year was the culmination of the Colorado strike in what can not be interpreted as other than a crushing defeat to organized labor. International Vice-President Hayes of the United Mine Workers of America is on record with the statement "that the Union had spent $3,044,000 on the strike."

The enormous expenditures of the miners' organization in Colorado also interfered with the payment of benefits to the idle union men in Ohio during the early part of the suspension and considerable dissatisfaction was reported from many of the mining districts; this situation was

somewhat relieved by modest donations toward the close of the year, but the miners have reached a point where their leaders are holding them in line with the greatest difficulty, and there are well-defined rumors of internal dissension in the organization.

Coal Markets in 1914

Pittsburgh.[1]—Throughout the Pittsburgh coal district the year 1914 was by all odds the worst for some time, presenting a sharp contrast with 1913, which was a season of heavy production and quite satisfactory prices. In 1914 prices were altogether unsatisfactory and the tonnage was light, the output being between 50 and 60 per cent. of nominal capacity, though probably less than 50 per cent. of that which could be produced with all physical conditions satisfactory.

The main cause for the coal trade being thus depressed was the poor industrial situation. The steel mills, upon which the Pittsburgh coal district largely depends for custom, did not operate at an average capacity of more than 60 per cent. during the year, while railroad consumption was materially curtailed and the Lake demand was altogether unsatisfactory.

For the low prices ruling in 1914 there was a contributory cause, namely, the settlement of the mining scale without a cessation of operations when consumers had expected a suspension. This, of course, did not alter the amount of coal produced or consumed in the year, but it upset a market that was already weak, so badly that no definite recovery occurred throughout the remainder of the year.

In 1914 a suspension was likewise expected, and stocks were laid in against it, but in addition to the settlement being reached 4 days before the termination of the old scale an arrangement was made whereby the miners were to remain at work during the taking of the referendum vote. As late as the beginning of September some operators were still attributing the light market demand to the fact that the stocks laid in prior to April 1 had not been entirely consumed.

Nor did the anticipation of a suspension cause any particularly strong market during the period when stocks were being accumulated. The year opened with circular prices at 90 cts. for slack; nut, $1.15; mine-run, $1.30; ¾-in., $1.40; 1¼-in., $1.50, with a 10-ct. concession to dealers on screened coal, but these prices were frequently cut. In February the cutting became more pronounced and even in March the market was not altogether steady. In the first two months mining operations were at 50 to 60 per cent. of capacity, while in March they did not much exceed 75 per cent. In April demand was so light that operations dropped to an

[1] B. E. V. Luty, *Coal Age*, Jan. 9, 1915, p. 79.

average of less than 50 per cent. and the only hope of the operators lay in the Lake trade.

Shipments of coal to the Lakes in 1914 amounted to about 23,000,000 tons, a decrease of about 6,000,000 tons from 1913. The Pittsburgh district furnished 49 per cent. of the total, Ohio falling far behind its usual proportion, on account of the deadlock on system of wage payment.

How extremely bad the market situation was is illustrated by the so-called "circular prices" announced late in the year. In 1912 the price announcement occurred Nov. 4, while in 1913 it was made on Oct. 1. The circular price for 1912 was $1.15 for mine-run, an advance to $1.22½ being announced in April, after the wage increase, while the fall circular carried an advance to $1.30. The announcement of Oct. 1, 1913, was of a 10-ct. advance to $1.40, but this increase did not hold even for a day. The circular price for 1914 was therefore $1.30, but it was scarcely obtained even in March. About Nov. 10 one of the larger operators made a price announcement of 85 cts. for slack, $1.05 for nut and slack, $1.15 for nut, $1.20 for mine-run, $1.30 for ¾-in. and $1.40 for 1¼-in., at the same time openly quoting 5 cts. a ton discount for prompt lots. These prices did not obtain, however, other operators preferring to maintain the figment of the old circular prices until such time as the market should improve and it might be possible to name prices that would be somewhat remunerative and would have a chance of being held.

Connellsville coke production in 1914 was light, while the prices realized were unsatisfactory. The output was about 14,000,000 tons, or the smallest since 1904, with the single exception of 1908. The average price realized was also the lowest since 1904 with the exceptions of 1908 and 1911.

Many of the Connellsville operations are heavily bonded, and in order to meet sinking-fund and interest charges a considerable portion of the price realized on coke must be set aside. The prices obtainable in 1914 did not, as a rule, provide sufficient margin for this purpose, and a curious feature of the trade was that many of the producers who most needed revenue refused to sell at going prices and thus had particularly light operations, with the result that their financial showings must have been extremely poor. Little is publicly known of their financial statements or operations, but there is room for conjecture that there were many defaults in interest payments. A few operating companies have been definitely forced to the wall, being bought out by the bondholders.

Some allowance should be made for the fact that a general wage advance was made early in 1913, so that costs were higher in 1914 than in earlier years. However, while the leading coke interest, the H. C. Frick Coke Co., a subsidiary of the Steel Corporation, adhered to the advanced

wage scale, several of the merchant operators made reductions early in the year, and the supply of labor was so plentiful that they experienced practically no difficulty in obtaining men to work at lower rates than were being paid at the majority of plants.

Boston, Mass.[1]—The year 1914 fell far short of the satisfactory record that distinguished the preceding 12 months. It ended as it began, in a slow inactive market for all varieties, with overproduction and low prices in bituminous consistently the chief factors all through the year, and relieved only by one or two short periods of "prospects"—periods that became in fact the despair of operators and selling agents. The slack industrial situation combined with other conditions to make 1914 a colorless and mediocre season in the coastwise coal trade.

There are few features that stand out in a review of conditions during a year in which coal was so sluggish. The long-heralded suspension of mining in central Pennsylvania had actually very little effect on the tide-water market. So long as there was a pronounced surplus of Southern coals it mattered little to New England if every bituminous operation in Pennsylvania should shut down. Stocks were large, and a controversy over weighing and checkoff was not serious enough to cause apprehension in so dull a market. The "suspension" showed its less serious side when in many instances mine workers on good terms with their employers were accommodating enough to cut coal for such orders as seemed urgent and then resumed the "suspension." A large number of the mines affected would have closed down for most of the time anyway, purely through lack of business. Differences were gradually adjusted and no more was heard of labor troubles the rest of the year.

Speaking broadly, the Seaboard bituminous trade throughout was under severe depression—a situation it shared with most other industries. The market was slow and apathetic, regardless of season. In New England the trade has become more and more involved with the increased use of steam colliers. The larger consumers are receiving fuel almost exclusively in this way and with the advantage of regular movement it is possible we shall not again have the kind of winter market that could formerly be counted on, due as it was, in large part, to the slow movement of sailing vessels during the storm season. Facilities are now well adjusted to these modern methods and aside from its effect on fuel *consumption* the weather is not now the factor it used to be.

Soft spots in the market appeared prominently early in March and there followed a long period of extreme dullness. The mills had more water power than they could use, as it was the heaviest in years, and as a result even the contract demand was light. Late in April some extra

[1] G. G. Wolkins, *Coal Age*, Jan. 9, 1915, p. 68.

requisitions from the Navy Department caused talk of better conditions, but it was soon over and by July the season was commonly referred to as "the dullest on record." It was realized that only the most rigid curtailment could mend matters, and for the time this was enforced there was a steady improvement in the position of all grades.

But it was not allowed to last. The European war seemed to open a wide vista; American shippers saw a broad market before them and one that grew more and more extended as they dreamed. A few New England buyers became worried and tried to make extra purchases, but their offers were refused and shippers began saving output 2 months ahead to send to the far corners of the earth.

For a few weeks there were some export orders, prices hardened at $2.85 Hampton Roads, and there were rumors of 10 @ 15 cts. premium, but gradually there came a change. It appeared that German and Austrian ships were driven out of trade, that the English government was chartering all the tonnage it could lay hands on, in all 1500 steamers it was said; in other words, suitable carriers were scarce with rates high, and American shippers could not compete.

It appeared also that exchange was difficult to arrange; in South America merchants were requiring 2, 3 and 4 months credit and then usually a renewal, a circumstance not at all attractive. The American shipper had always looked upon off-shore business as quick cash, and the results of some of the August transactions were disappointing. So the export trade sagged off, and with this prop removed from an otherwise weak market, late October saw the bituminous trade again in the doldrums and the outlook more discouraging than before.

The hard-coal trade in general afforded a pleasing contrast to the situation in bituminous. While early in January the demand was listless, due to the mild weather, lower temperatures began to prevail and lasted well into March. Orders were plentiful in consequence, and not in years was there so little coal in consumers' cellars as in the spring of 1914. April business, therefore, was excellent and all the companies that regularly ship to this market had a most satisfactory trade through to July 15. Receipts of anthracite the first 6 months at the Port of Boston were more than 50,000 tons in excess of the corresponding period of 1913, and that is an indication of the increase all over New England.

Wholesale prices on anthracite, delivered alongside Boston, remained substantially the same as established in 1912, namely, $5.25 as the net circular per ton of 2240 lb. The only change involved the Pennsylvania state tax first assessed in July, 1913. Some shippers added a flat 10 cts. to the price and others charged the exact amount laid upon them.

Boston retail prices were advanced in July and again in August, 25 cts.

in each case, as against three similar advances in 1913. Egg size, however, was brought to the level of stove, so that $7.75 was the price of egg and stove and $8 the price of chestnut by the end of December.

As usual, coastwise freights in 1914 kept step with the coal market. Rates were uniformly low. There was no such level as the 95 cts. @ $1 rate that prevailed early in 1913; in fact, it would probably be difficult to find an instance where more than 80 cts. was paid a sailing vessel or barge, 2500 tons and upward, Hampton Roads to Boston, at any time in the calendar year. On the other hand, during June and July large vessels could be had for single trips at 55 cts. and steamers were let at 50 cts., the lowest rate per ton in 20 years. There was a surplus of steam, sail, and barge tonnage at all times, and only when storms worked havoc or delayed movement was there any change; 65 @ 70 cts. was the highest range that obtained for any period longer than a week.

Late in the year, there were a few small signs of improvement. Scattering plants, mostly special lines of textiles and shoe factories, were running to capacity on foreign orders, and it was predicted that other industries would gradually fall into line. The process will be gradual, however, and New England buyers are likely to be even more conservative this year than last; they have observed the course of prices in 1914 and unless the unforeseen occurs, the spring of 1915 will probably be a slow season for placing yearly contracts.

In general, 1914 held up to the coal trade some rather plain truths. The operators were especially impressed with the fact that their output and profits depend on the general prosperity of the country, and that only by keeping in intelligent touch with market conditions and regulating their output accordingly can they secure a reasonable net return on their product.

Hampton Roads.[1]—The year of 1914 saw great activity at Hampton Roads, as well as many improvements for the prompt handling of both cargo and bunker vessels. Early in the year the large steel pier of the Norfolk & Western Ry. was completed at Lamberts Point, and almost immediately great improvement was noticed in the rapidity with which vessels were dispatched on calling there. This pier has made numerous records for heavy dumpings, such as 872 cars in the space of 24 hr. It had hardly been working 6 months when the Chesapeake & Ohio Ry. completed its dumping facilities at Newport News. With these piers and those of the Virginian Ry. at Sewalls Point, Hampton Roads is now in position to lead the world in the dumping of coal into all classes of vessels.

There have been constant changes in the prices of the various grades

[1] J. W. Bunting, *Coal Age*, p. 76, Jan. 9, 1915.

of coal handled out of Hampton Roads and while it is difficult to arrive at a definite average price for the year, a fair estimate would be about $2.80 to $2.85 for New River and Pocahontas run-of-mine and $2.60 to $2.65 for high-volatile coal. There have been times, of course, when prices have gone considerably above these quotations, especially just at the outbreak of the European war, when some of the suppliers were quoting as high as $3.10 per ton on New River and Pocahontas, although it is not believed that any great amount of coal was sold at this figure.

The South American market since the beginning of the war in Europe has been a large buyer of coals from Hampton Roads, although there now appears to be some falling off in the demand from this source. This is no doubt due to the buyers not having used the supply which they took in early in the fall, and the prospects are that they will again be drawing heavily from this market during the beginning of the new year.

It was hoped that 1914 shipments would show an increase over 1913 of at least one million tons, but from statistics now obtainable it appears that the figures for the two years will not be markedly different though, perhaps, there will be a gain of about 300,000 tons for 1914.

An explosion in the Eccles mines of the New River field during April greatly reduced the output from that region for some weeks, and to some extent helped to cut down the total movement for the year.

Large orders have been placed at Hampton Roads ports by foreign buyers all through the year, the most notable, no doubt, being those from Italy and Greece. Coal has for many years moved in large quantities to the Italian market, but there has been little demand from Greece until the present year when a contract was made for furnishing this market with about 100,000 tons. Until the outbreak of the war there was a growing demand from Austria, but under present conditions this has been entirely cut off. Norway and Sweden have also taken some few cargoes. Some coal has also been shipped to the Canary Islands. This is not usual, though they had bought coal in the United States before whenever there was a difficulty in getting it from England or Wales.

There have been 5 months, viz.: March, April, May, August and September, when the total shipments amounted to more than one million tons per month, and up to Dec. 1 there were only 2 months where the dumpings fell below 925,000 tons. Of the total dumpings during 11 months the Norfolk & Western Ry. has moved within about 100,000 tons of the combined movement of the Chesapeake & Ohio and Virginian Railways. Without taking into consideration the dumpings for December, the Norfolk & Western Ry. on Nov. 30 was within about 20,000 tons of its yearly movement for 1913.

Taking the year 1914 as a whole it has hardly come up to the expecta-

tions of the shippers from Hampton Roads, but there is some satisfaction in knowing that even with conditions entirely different from the previous year there will be a gain of at least a quarter of a million tons.

Buffalo.[1]—The dullness that pervaded the Buffalo market well back in 1913 in the bituminous and coke trade has continued. As a rule, no reports have been received from any source that did not complain of decline in demand or of factories shutting down. All bituminous coal and coke business has stagnated so badly that a report of conditions, in detail, would fail to discover anything like the variety that is common in a normal year's transactions.

In some respects it has been fortunate, and in some quite the opposite, that certain of the leading coal operators in Pittsburgh have a way of signifying about Apr. 1 what they will call the Buffalo price for an indefinite time. This forms a foundation to work on, but when prices sag and the informal circular remains unchanged, it is not easy to say what should be done.

The only course that seemed feasible during the past year was to continue the Pittsburgh figures, namely, $2.80 for lump, $2.70 for three-quarter, $2.55 for mine-run and $2.15 for slack, at which prices the best Pittsburgh coal has always sold to some extent. There has been no particular change in the relative market prices of Pittsburgh and Allegheny Valley coals, the latter running from 20 to 30 cts. lower than Pittsburgh for prepared sizes, all slack selling about on a par.

There has been no change in the number of blast furnaces in this district, though some of them have not been active of late. The amount of iron ore received here by lake during the season of 1914 was 2,770,000 tons, as against 5,200,000 tons in 1913, which tells the smelting story pretty well.

The decline in the demand for coal from Canada has been greater during the year than from the Buffalo territory in our own country. Canada has for some time been suffering from land booms and the war has affected the Dominion much more than it has the United States. Buffalo sells a large part of its coal in Canada and was consequently materially affected by the changed conditions.

The anthracite trade has been satisfactory for the most part and the outlook for it at the close of the year is fully up to the normal. There has been practically no change in the Buffalo situation during 1914. In the former year several independent anthracite companies located branch offices here. These are still doing business and local bituminous shippers have continued their anthracite sales, so that the trade appears to have been kept up. The independent anthracite price has not lately been at

[1] J. W. Chamberlain, *Coal Age*, Jan. 9, 1915, p. 75.

a premium, though sometimes during the previous year it was easy to obtain 50 cts. or so extra on prompt shipments.

Lake shipments of anthracite closed on Dec. 9, the amount shipped, according to the custom-house record, being 4,386,226 net tons. The amount for the season of 1913 was 5,033,696 tons, which was the largest in the history of the trade. It is likely that there is as much coal on Upper-Lake docks now as there was a year ago.

Coal Movement in 1914.—The following is a summary of the shiments of bituminous coal over the 12 leading coal roads for the past 4 years, in short tons:

Bituminous	1912.	1913.	1914.
Baltimore & Ohio[1]	34,128,269	36,915,385	32,554,359
Buffalo, Roch. & P[1 2]	8,289,296	9,723,992	8,059,756
Buffalo & Susq.[1 2]	1,530,441	1,787,551	1,190,181
Chesapeake & Ohio[1]	17,011,888	17,155,233	20,663,520
Erie[3]	266,150	350,590	75,818
Hunt. & Br'd T. Mt.[1 2]	1,277,180	1,352,721	1,036,658
New York Central[3]	8,308,260	9,220,689	8,120,210
Norfolk & Western[1 2]	22,643,169	23,892,469	25,471,969
Pennsylvania[1 3]	46,434,187	51,526,267	47,769,227
Pitts. & Lake Erie[1 2]	11,424,681	12,783,389	10,703,478
Pitts. Shaw. & North[1 2]	2,026,010	2,799,308	2,359,807
Virginian[1 2]	3,584,009	4,555,331	3,954,310
Western Maryland	2,767,980	2,953,601	3,069,708

[1] Includes coal received from connecting lines.
[2] Includes company's coal.
[3] Does not include company's coal hauled free.

SHIPMENTS OF ANTHRACITE
(Tons of 2000 lb.)

	1911.	1912.	1913.	1914.
Reading	13,265,758	12,852,386	12,914,887	11,998,779
Lehigh Valley	12,603,000	11,791,601	13,011,370	13,136,759
N. J. Central	9,218,802	8,342,447	9,092,433	8,924,936
Lackawanna	9,869,620	9,065,622	9,903,541	9,912,578
Del. & Hudson	7,206,731	6,361,238	7,094,258	7,313,541
Pennsylvania	6,494,733	7,435,697	6,351,756	6,434,937
Erie	8,800,179	7,435,697	8,192,352	8,268,585
N. Y. Ont. & West	2,495,476	2,213,382	2,509,031	2,352,486
Total	69,954,299	63,610,587	69,069,628	68,342,601

Norfolk & Western Ry.—The following is a statement of the tonnage shipped over this road during the past 3 years:

	1912.	1913.	1914.
Coal,			
Tidewater, foreign	1,343,311	1,542,950	1,904,306
Tidewater, coastwise	3,583,283	3,805,847	3,763,420
Domestic	17,716,575	18,543,672	19,804,243
Coke,			
Tidewater, foreign	52,762	31,082	1,415
Domestic	1,416,856	1,499,302	1,017,196
Total	24,112,787	25,422,853	26,490,580

Chesapeake & Ohio Ry.—The following is a comparative statement of the coal and coke traffic from the New River, Kanawha and Kentucky districts for the 6 months ending Dec. 31, 1912, 1913, and 1914, in short tons:

	1914.	Per Cent.	1913.	Per Cent.	1912.	Per Cent.
Destination:						
Tidewater	1,797,457	16	1,614,503	17	1,690,591	20
East	1,280,469	12	1,254,609	14	1,215,205	15
West	7,325,153	67	5,681,077	62	4,947,470	61
Total	10,403,079	.....	8,550,189	.....	7,853,266	.....
From Connections:						
Bituminous	588,433	5	624,276	7	241,671	3
Anthracite	8,835	.....	8,370	.....	6,971	1
Total	11,000,347	100	9,182,835	100	8,101,908	100
Coke	90,877	.....	180,997	.....	134,936	.....

Imports and Exports.—The following is a comparative statement of imports and exports of the United States for 1912–13–14, in long tons:

	1912.	1913.	1914.
Imports from:			
United Kingdom	8,697	6,141	27,421
Canada	1,404,139	1,096,924	1,050,592
Japan	30,621	117,483	75,109
Australia and Tasmania	162,671	188,613	219,941
Other countries	2,222	4,696	2,253
Total	1,608,350	1,413,857	1,375,316
Exports:			
Anthracite:			
Canada	3,615,530	4,083,333	3,767,774
Brazil	.....	.....	6
Uruguay	.....	84	.....
Other countries	73,259	70,969	62,464
Total	3,688,789	4,154,386	3,830,244
Bituminous:			
Canada	10,433,010	13,496,190	9,170,901
Panama	486,309	489,761	267,598
Mexico	302,487	477,046	359,802
Cuba	1,152,004	1,275,538	1,074,825
West Indies	651,268	608,762	552,600
Argentine	.....	70,048	241,248
Brazil	.....	279,933	278,026
Uruguay	.....	16,858	76,088
Other countries	1,434,900	1,272,621	1,780,762
Total	14,459,978	17,986,757	13,801,850
Bunker coal	7,340,100	7,700,520	7,266,002

Review of Coal Mining by States

Alabama.[1]—The coal mines of Alabama produced during 1914 15,593,422 tons of coal, approximately 2,000,000 tons less than in 1913. If business had been normal the output would have been at least 20,000,000 tons, as the mines averaged only about 4 days per week during the entire year. Alabama will probably stand in the fifth place among coal-producing states, one place lower than in 1913.

[1] B. M. Staynes, *Coal Age*, Jan. 9, 1915, p. 42.

PRODUCTION OF COAL IN THE UNITED STATES
(Short tons.)

State.	1913 (b).		1914.	
	Quantity.	Value.	Quantity.	Value.
Alabama	17,678,522	$23,083,724	15,593,422	$20,849,919
Arkansas	2,234,107	3,923,701	1,836,540	3,158,168
California and Alaska	26,911	95,173	25,000	.....
Colorado	9,232,510	14,035,090	8,200,000	.....
Georgia	255,626	361,319	166,498	239,462
Idaho and Nevada	1,177	5,285	2,000	.....
Illinois	61,618,744	70,313,605	57,589,197	64,693,529
Indiana	17,165,671	19,001,881	16,641,132	18,290,928
Iowa	7,525,936	13,496,710	7,451,022	13,364,070
Kansas	7,202,210	12,036,292	6,824,068	11,181,687
Kentucky	19,616,600	20,516,749	20,382,763	20,852,463
Maryland	4,779,839	5,927,046	4,133,547	5,234,796
Michigan	1,231,786	2,455,227	1,283,030	2,559,786
Missouri	4,318,125	7,468,308	3,935,980	6,802,325
Montana	3,240,973	5,653,539	2,805,173	4,913,191
New Mexico	3,708,806	5,401,260	3,877,689	6,230,871
North Dakota	495,320	750,652	506,685	771,379
Ohio	36,200,527	39,948,058	18,843,115	21,250,642
Oklahoma	4,165,770	8,542,748	3,988,613	8,204,015
Oregon	46,063	116,724	51,558	143,556
Pennsylvania, bituminous	173,781,217	193,039,806	147,983,294	159,006,296
Tennessee	6,903,784	7,883,714	5,600,000	.....
Texas	2,429,144	4,288,920	2,323,773	3,922,459
Utah	3,254,828	5,384,127	3,103,036	4,935,454
Virginia	8,828,068	8,952,653	7,959,535	8,032,448
Washington	3,877,891	9,243,137	3,040,061	.....
West Virginia	71,308,982	71,872,165	71,707,626	71,391,408
Wyoming	7,393,066	11,510,045	6,475,293	10,033,747
Total bituminous	478,523,203	565,307,658	422,329,650*	.....
Pennsylvania, anthracite	91,524,922	195,181,127	85,036,127	.....
Grand total	570,048,125	760,488,785	507,365,777*	.....

b. Figures of the U. S. Geol. Surv.

PRODUCTION OF COKE IN THE UNITED STATES
(Short tons.)

	1913 (b).		1914.
	Quantity	Value.	Quantity.
Alabama	5,218,823	$7,609,963	3,084,149
Colorado	1,349,743	2,158,120	666,063
Georgia	82,871	162,439	24,517
Illinois	2,481,198	7,225,925	1,425,168
Indiana	3,535,136	11,006,033	2,276,652
Kentucky	512,245	584,684	443,950
New Jersey	339,351	868,346	255,283
New Mexico	788,172	1,085,239	362,572
New York	1,067,207	2,640,679	457,370
Ohio	507,417	977,990	521,638
Pennsylvania	43,195,801	52,374,986	20,258,393
Tennessee	694,085	668,255	264,127
Virginia	2,015,259	1,772,837	780,984
Washington	118,786	295,402	84,923
West Virginia	4,034,251	3,615,901	1,427,962
Other States a	3,299,345	7,514,640	2,222,134
Total	69,239,190	$100,561,439	34,555,914

a Includes Maryland, Massachusetts, Michigan, Minnesota, Utah, and Wisconsin.
b Figures of the U. S. Geol. Surv.

While it is hard to obtain the actual number of non-fatal accidents, for many of the trivial ones are never reported to the mine inspector's office, it is estimated that their number is approximately 2000. The fatal accidents for the year will be about 120, which is about the same as in 1913. There were two explosions during the year in which five or more were killed, namely: Jan. 10, Rockcastle mine, 12 killed, none injured; Oct. 5, Mulga mine, 17 killed, 12 injured.

Alabama has had no labor troubles during the past year but, on account of the dull business, operators were unable to increase wages, as had been done in 1913. However, many playgrounds, schools, etc., were secured for the miners, and aside from not being able to make full time, labor is well satisfied.

Water transportation of coal from this district to the Gulf has been held back by one cause or another, and while there has been considerable tonnage moved over this route, it is not as large as had been expected. The completion of Lock 17 during the early spring of 1915 will give this district navigable water the year round to the Gulf, and it is expected that a heavy tonnage will be moved over this route in 1915.

Despite the unfortunate business conditions, there were also several new mines put into operation. The Maryland Coal Co. spent approximately $100,000 on new openings and general improvements, and the Panama Coal Co. started developments on a large tract of coal land. When completed, the outlay will be about a million dollars.

The South Brilliant Coal Co. has opened up a new mine near Brilliant, in Marion County, known as Parker No. 1, and the Alabama Fuel & Iron Co. two new mines at Acmar, St. Clair County, known as Acmar No. 2 slope and No. 2 drift. In Jackson County, the Pierce Coal & Lumber Co. has started one of the most complete mines in the district and has built a 20-mile railroad connecting its road with the Southern Ry.

In November the first barge went up the Warrior River beyond Tuscaloosa. Within 4 hours it had been loaded with 700 tons of coal and was on its way to New Orleans. Following the decision of the Interstate Commerce Commission that the Birmingham Southern Ry. was a common carrier, officers of that road announced that many costly improvements and extensions would be made, the work on which would be started at once.

The railroads of the Birmingham district petitioned the Interstate Commerce Commission and the Railroad Commission of Alabama that they be allowed to increase their freight rates to practically every point in the South from 10 to 30 per cent. It is estimated that should these increases be allowed, they will curtail the output of coal in this district at least 500,000 tons. No decision has yet been rendered.

Arkansas.[1]—The coal mines of Arkansas during the fiscal year ending June 30, 1914, produced 2,136,783.59 short tons, valued at $3,631,100. This was a remarkable record, considering the labor troubles during the year. There are 117 coal mines, 51 shafts, 53 slopes, 12 drifts, and 1 strip pit. There are 3300 miners, 1770 daymen, and 286 officemen and mine officials. Total number of persons engaged in the coal-mining industry, 5356.

The fatal and non-fatal accidents have greatly increased in proportion to the production during the past fiscal year. There were 15 fatal and 130 non-fatal accidents. The most prolific causes of accidents were the following: Dust and gas explosions, falls of rock on traveling roads and at the working face, being run over by trips of cars on slopes.

There were two mine explosions caused by windy shots, gas or dust, in which the shot firers were killed. One miner lost his life while making up powder for a shot with an open light on his head, the spark dropping into his keg of powder. One top man fell into a slack bin and smothered to death.

The number of men locked out and on strike for one cause or another during the past fiscal year was 2354, over 46 per cent. of the total number employed at the mines. The number of days lost through strikes and lock-outs up to July 1 was 619.

The capital invested in the Arkansas coal-mining industry totals $2,379,570. The mines of the state are ventilated by 58 fans and 21 furnaces, while 36 mines employ natural ventilation. For haulage purposes in the mines, 415 mules are employed.

Colorado.[2]—The coal industry of Colorado during the year just closed was not a profitable one financially. The strike dealt it a severe blow. When the mines were able to resume normal production by reason of bringing into the coal camps sufficient numbers of men to take the places of the striking miners, the European war came to minimize the business of such steam plants as depended upon Colorado coal for their fuel, and in addition, an unusually warm fall made the local markets slack. The prolonged war in Mexico also affected the production of this state, as much coal was sold in Texas which went into Mexico.

However, 1915 finds Colorado free from industrial strikes and better business is now expected. The coal strike called in Trinidad, Sept. 23, 1913, was formally declared off in Denver, Dec. 10, 1914. This also ended the strike in the northern field, which had been pending over 4½ years. No concessions were made by the operators to the striking miners to effect this settlement, but the latter abandoned their

[1] Thomas H. Shaw, *Coal Age*, Jan. 9, 1915, p. 45.
[2] A. R. Tibbits, *Coal Age*, Jan. 9, 1915, p. 46.

fight upon the advice of the executive body of their organization. It was a wise move and may do much to establish friendly relations between the operators and miners.

The new coal-mining law has now been in effect a little over a year and has been the means of making material improvements in most of the mines; some of the operators of small mines, either because of limited funds, or failure to grasp the importance of placing each and every mine, no matter how small, on a safe and sanitary basis for best results physically and financially, have not complied fully with all the provisions of the new law; however, the operators of large properties have been very active in improving their mines, installing numerous safety devices, enforcing regulations for the safeguarding of the underground workers.

The rate of fatality is less than in 1913, but not as low as could be expected under the improved conditions of the mines and can be explained by the fact that many inexperienced men took the places of the more experienced miners who went out on strike.

The normal production of Colorado is about 10,500,000 tons annually. The decrease in 1914 is 1,109,450 tons; the decrease in 1913 was 1,740,009 tons; the total production in 1912 was 11,016,948 tons, slightly over normal.

In consequence of the dull market a number of large mines have been closed down, especially in Fremont County. The coal of this county is of a very fine domestic grade and has been in great demand. In 1912, 773,188 tons was produced and in 1914 only 168,050 tons. Las Animas County, the great coking coal producer, dropped from 4,770,292 tons in 1912 to 2,817,678 tons in 1914. A splendid exception to the foregoing is Routt County, the last to join the widely scattered coal-producing counties of this state. It has to its credit an increase of 314,939 tons and a total production of 647,505 tons in 1914. This coal is of the non-coking bituminous variety which can be stored in the summer months, and much of it is sold out of the state.

Colorado has enormous coal fields which have hardly been touched and the coal is of the best varieties, ranging from a good lignite to anthracite, and no doubt when business improves and the manufacturing of goods is encouraged in the West, Colorado will take her place as one of the great coal producers in the United States. All this state needs is markets for its production.

Illinois.[1]—Coal mining in Illinois made no gain in the year ending June 30, 1914, but rather declined, due to hard times, the output showing a decrease of 1,130,409 short tons from that of the preceding year.

The reasons for the loss in tonnage are as follows: (1) Labor troubles,

[1] Martin Bolt, *Coal Age*, Jan. 9, 1915, p. 47.

caused by the making of new contracts. (2) A general depression which closed down a large number of the factories entirely, and placed many others on half the regular working time or less, thus cutting down the demand for coal. (3) The fact that other states have access to Illinois markets, thus restricting the natural output of coal in this state.

The probable output in short tons from the shipping mines for the calendar year 1914 will be, in round numbers, 59,500,000 tons. These figures are based on the fact that the shipping mines during the first half of the year 1914 showed a loss in production of nearly 1,500,000 tons, as compared with the same period in 1913. The loss for the last half of the year may be assumed as 1,000,000 tons, but it may well exceed that figure because of the mild weather, and, further, because there are a large number of shipping mines throughout the state that have not been placed in operation since they were closed down on Apr. 1.

There have been no serious labor troubles in the mines of Illinois in the year 1914, although there was some delay in reaching an agreement, and some of the mines were closed down pending the signing of the new contract, while some continued to operate under the old scale.

Accidents in the mines of Illinois have increased and decreased at about the same ratio as the tonnage. The number of fatal accidents for the year ending June 30, 1914, was 159, as compared with 175 for the preceding year. Based on these figures, the number of fatal accidents for the calendar year should be less than they were in the year of 1913. This is not true, however, as an explosion which took place since the close of the fiscal year caused the death of 52 men, and this will bring the number of fatal accidents for the calendar year above what it was in 1913.

There will be shown also a large decrease in the number of shipping mines, and the loss on tonnage will be found to be all in this class of operations. The local mines will show a slight increase in tonnage for the year 1914.

There have been no new mines of any importance placed in operation during this year. There are one or two that will begin to operate some time in 1915; one of these mines is in Franklin and the other in Vermilion County.

Taking all things into consideration, the coal-mining business in Illinois is in a worse condition than it was one year ago, and there is no sign of an early improvement. The cold weather of the past few weeks has increased business, but more than cold weather is needed to bring about normal conditions.

Indiana.[1]—The demand for coal, the market prices, and mining con-

[1] Frank I. Pearce, *Coal Age*, Jan. 9, 1915, p. 48.

ditions for the fiscal year ending Sept. 30, 1914, were exceptionally poor. Both miners and operators suffered from the adversities of the coal trade.

The total production for the year was 16,635,178 short tons, or a decrease of 611,387 tons, in comparison with the production of the previous year. Of this tonnage, 16,322,347 tons was bituminous coal, which is 478,633 tons or a fraction over 2.8 per cent. under the production for the year 1913, and 312,831 tons was block coal, which is a decrease in production of 132,754 tons or a fraction over 29 per cent. less than the output for the previous year. Of the total production, 9,434,817 tons or a fraction over 56.7 per cent. was mined by mining machines and 7,200,361 tons or 43.3 per cent. by hand.

Vigo County last year, as also in the year 1913, led in production. Last year it exceeded Sullivan County, its nearest rival, by 1,571,333 tons. This was due to the increased development in Vigo County during the past 2 years.

Of the bituminous coal, 9,908,053 tons was consumed in Indiana and 6,414,294 tons was shipped to other states. Of the block coal, 137,715 tons was consumed in this state and 175,116 tons was shipped out. A fraction over 60 per cent. of the total production was consumed within the state limits. Thus, there is a slight increase in the percentage of home consumption over that of last year.

The total wages paid, as reported from the bituminous field, were $14,580,467.97, making the average cost of labor a fraction over 89 cts. per ton. The total wages paid in the block-coal field were $487,516.70, or a fraction over $1.55 per ton for the labor cost of production, which is an increase of about 4 cts. per ton over that of last year. These figures as a whole, however, show a slight decrease in the labor cost per ton for the total production of bituminous and block coal over that of last year.

The market prices for mine-run bituminous coal (except yearly contracts) f.o.b. cars at the mine during the year ranged from about $1 to $1.15. There was, however, during the year much coal sold for less than $1, especially during the months of June, July and August, while there was but a small amount of coal sold for $1.15. The market selling price for screened block coal (except on yearly contracts) f.o.b. cars at the mine from Oct. 1, 1913, to May 31, 1914, ranged from $2.10 to $2.25 per ton, and from June 1 to Sept. 30, 1914, from about $2.10 to $2.15 per ton. These figures show a marked decrease in the average selling price in comparison with that of the previous year.

The total number of employees for the year was 22,110, or an increase of 427 over those working last year. Of this number, 21,086 were bituminous and 1024 were block-coal mine employees.

The aggregate number of days the mines were reported as being in

operation was 23,927, and the number of days idle, due to lack of orders, 14,798; due to a scarcity of railroad cars, 1125; owing to local strikes, 194; to permit the workers to attend funerals, 27; and on account of other causes, 1818.

The total wage reported from the bituminous field being $14,580,-467.97, makes an average earning of $691.47 for each bituminous employee. The total wages paid to block-coal employees being $487,516.70, shows an average earning of $476.09. The aggregate wages for the state being $15,067,984.67 and the total number of employees 22,110, shows an average earning of $681.50 for each mine employee in the state, as compared with $736.06 for each mine employee for the year 1913.

Eight new mines (all of which with the exception of one or two will be large producers) were opened up during the year, and 22 were abandoned. Of the latter, there were a number that had a production of several hundred tons, and could have been worked both successfully and profitably for some time were it not for the large amount of expense necessary to keep them in repair during idle days that they might be ready to operate when orders were obtainable.

During the year there were 49 fatalities. This does not include accidents occurring in mines employing less than 10 men and in clay mines and strip banks over which this department has no jurisdiction. The mining of clay and shale is rapidly becoming an important industry in this state. There are also several strip banks. In these operations, and in mines employing less than 10 men, there is a total production of about 420,000 tons and about 2500 to 3000 persons are employed. In most of the clay mines there is a small production of coal, which is used in the manufacture of clay products.

Iowa.[1]—The statistics for the fiscal year ending June 30, 1914, show that Iowa produced for that period 7,312,754 tons of coal. There were 258 mines in operation in 23 coal-producing counties in the state; 15,740 men were given employment in and around the mines of Iowa. The statistics relating to accidents in the mines show that there were 34 fatal and 161 non-fatal accidents for the fiscal year. The fatality rate per thousand employees was 2.1 per cent.

There was little change in the coal production during the first half of 1914, as compared with that of the first half of 1913. Working conditions were pretty much the same, and one is therefore led to believe that for the calendar year 1914 the state will show a production of at least 7,500,-000 tons of coal, with more than 15,000 men employed and an average working time of probably about 220 days. This takes in to consideration the prevailing warm weather of September, October and November,

[1] L. E. Stamm, *Coal Age*, Jan. 9, 1915, p. 50.

when the demand for coal was light and the majority of the mines were working but 3 and 4 days each week.

From July 1, 1914, to the present time, but 14 fatal accidents have occurred in the Iowa mines. This compares favorably with the statistical data on fatal accidents, which show the average fatal accidents in the Iowa mines in the past 19 years to be 30.3, while for the past 10 years the average fatalities have been 32.5.

During the year 1914 considerable progress was made in and around the mines in bettering the facilities for coal production. In the agreement entered into between the miners and operators in April, 1914, to continue for 2 years, a scale of wages for machine mining was included, and since the signing of that agreement a number of mines in the state have installed mining machines which will tend to increase the coal production of the state. Also a number of mines in the state have been equipped with electric hoists and electric haulage during the past year, while others have so reconstructed their top works, screens, etc., as to better facilitate the handling and grading of their product. There seems to be an increased incentive to still greater activity along these lines, as a number of other mines are contemplating like improvements.

But few labor troubles occur in the mining industry of this state. This is owing to the fact that both the operators and the miners have an organization, and a working and wage agreement is entered into by them for a period covering 2 years. The labor difficulties that do arise are chiefly local to the mines and are usually quickly adjusted by the representatives of both of these organizations. It has been the custom in former years to suspend operations at the mines while the miners and operators were agreeing upon a scale of wages and working agreement. However, a new precedent was established in April and May of 1914, when the representatives of both organizations met to perfect an agreement, the miners continuing their work while the agreement was being made. The new wage agreement will be in force until April, 1916, and it is not likely that any serious disturbance in the mining industry will occur during the life of the agreement.

Kansas.[1]—The records when completed will show that approximately 7,100,000 tons of coal was produced during the fiscal year ended June 30, 1914, and the production for the year ending Dec. 31, based on that produced during the fiscal year, will amount to 6,824,068 tons. This is a slight decrease in production, compared with that which the year 1913 shows.

The number of employees in the mines of the state will not be materially changed from that of the year 1913, which was 12,506. The number of days worked in the year will average 200.

[1] Francis Keegan, *Coal Age*, Jan. 9, 1915, p. 51.

During the year ended Dec. 31, 1914, there were 32 fatal accidents in and around the mines of the state. Compared with the year 1913, this is an increase of four fatalities. Mine explosions are still contributing their share to the number of deaths in the mines of the state. The necessity of installing electrical shot-firing devices in the mines is being more generally admitted, and I have no doubt that within a few years all the deep mines in the state at least will be equipped with electrical shot-firing devices, thus protecting the lives of the shot-firers.

Many improvements have been made in the mines of Kansas during the past year, especially in ventilation and sanitary conditions. The future looks bright for the industry of the state. Crawford County keeps forging ahead until to-day almost 70 per cent. of our coal production comes from this county. Several new mines have been opened during the past year, and the steam-shovel business is continually assuming larger proportions.

Owing to a disagreement between the Coal Operators Association and the United Mine Workers of America regarding the proper interpretation of the joint agreement, a strike was called by the mine workers' officials on Nov. 1 at the mines of the Cherokee & Pittsburgh Coal Mining Co., better known as the Santa Fé mines. At the present writing this strike is still in progress, but everyone is hoping that a satisfactory adjustment of the difficulties will soon be reached. Aside from this, there has been no serious interference with the operation of the mines of the state during the past year.

Maryland.[1]—The coal production of Maryland for 1914 was about the same as for 1913, the total output being 4,133,547 short tons.

There were no labor troubles during the year. Unfortunately, more fatal accidents happened during 1914 than in the preceding year, 11 fatalities being reported from May 1 to Dec. 31. Ten of these accidents were caused by falls of rock and one by cars.

The last session of the Maryland legislature passed a workmen's compensation law, which went into effect on Nov. 1, 1914. The casualty and indemnity companies have been slow to quote a rate on this mine insurance. To insure in the state fund means the payment of $5 per year on every monthly salary of $100, or in proportion thereto. In case of death, the widow will be paid 50 per cent. of the weekly average pay; minors, a certain definite proportion. The running indemnity is not to be less than $5 nor more than $12 per week in any case.

Michigan.[2]—The production of the state will doubtless prove to be about 1,200,000 tons when the reports from all sources in this state have

[1] Wm. Walters, *Coal Age*, Jan. 9, 1915, p. 51.
[2] Thos. Kanary, *Coal Age*, Jan. 9, 1915, p. 52.

been received. Of this, about a million tons was mined by machines. There were no labor disturbances in the past year. Only one new opening was made. This was near the Fordney and Chapel No. 2 mines in the city of Saginaw.

The Handy Bros. Mining Co. abandoned their No. 1 Shaft at Akron, in Tuscola County, and the Jackson Coal Co. ceased to operate the shaft in Calhoun County near Albion, but the latter will be reopened later.

Missouri.[1]—The coal output of Missouri for 1914 is approximately 4,000,000 tons, or about the same as the 1913 production. The year was practically free from labor disturbances, but fatal accidents in the mines increased, there being 19 fatalities, as compared with nine fatal accidents in the year preceding. On the other hand, there were fewer non-fatal accidents during 1914, the non-fatals for the last year being 36, as compared with 73 for 1913.

Montana.[2]—The state of Montana employed 3660 men during the year 1914, producing 2,805,173 tons, valued at $4,913,191. The number of tons produced per life lost was 244,889, and for each serious accident, 56,513. The number of men employed for each fatal accident was 305; for each non-fatal accident, 70. The percentage of men killed per 1000 employed was 3.27; number seriously injured per 1000 employed, 14.

New Mexico.[3]—The demand for coal and coke from New Mexico has been somewhat restricted on account of the revolution in Mexico and the war in Europe. Considerable coal is exported from this state to Mexico when conditions are normal, and the copper mines of Arizona which are supplied with coal and coke from this state have been obliged to reduce their orders on account of their inability to export copper to Europe, owing to the European war. Yet the demand for our coal is gradually increasing, and the production is greater this year than ever before.

The gross production for the fiscal year, Nov. 1 to Oct. 31, amounted to 3,826,885 tons, valued at the mines at $5,588,352.17. The production of coke during the fiscal year amounted to 405,127 tons, valued at the ovens at $1,341,731.62; value of coal and coke combined, $6,930,083.79.

Labor conditions have been fairly good. There has been no labor trouble between the companies and their employees for many years. During the winter months more men could be employed at most of the mines, but there is a scarcity of miners in this state during the winter months.

The industry has been fortunate this year in not having any mine explosions. This has been due, to a great extent, to taking better pre-

[1] J. P. Hawkins, *Coal Age*, Jan. 9, 1915, p. 52.
[2] John Sanderson, *Coal Age*, Jan. 9, 1915, p. 52.
[3] R. S. Beddow, *Coal Age*, Jan. 9, 1915, p. 53.

caution in blasting and in guarding against the dangers arising from the accumulation of coal dust in the mines. This problem is a difficult one in this state on account of the atmospheric conditions prevailing. The humidity of the atmosphere is relatively low and large volumes of air entering the mines absorb the natural moisture of the workings, leaving the coal dust in a very dry and inflammable condition, thus making the coal-dust problem the most dangerous one we have to face.

Ohio.[1]—The coal trade in Ohio for the year 1914 was a disappointment to all concerned. In the face of excellent prospects at the beginning of the year, labor troubles intervened which, together with a business depression of a widespread nature, have combined to cut the total production to about 50 per cent. of the total of the previous year. In 1914 the total Ohio production was reduced to 18,843,115 tons, which compares with 36,285,468 tons in 1913.

At the beginning of 1914, the outlook was excellent and the demand for all grades was fairly good. There were prospects of a suspension after April 1 when the mining scale was scheduled to expire, and the stocking movement stimulated trade to a certain extent. So the months of January, February and March were characterized by activity in all fields. Practically full time was worked by most of the operators during that period and steam users stored quite a surplus of fuel. Prices ruled firm, and while they were not high they were sufficient to yield a small and substantial profit.

April 1 all of the mines of the state closed down because of the expiration of the wage agreement and the failure to formulate a new one. After a number of conferences, in which operators from all the coal-producing districts of the state participated, a break in the ranks of the operators occurred. The Hocking Valley district including Jackson, Pomeroy Bend and Crooksville decided to treat alone and agreed to pay 47 cts. per ton for machine-mined coal on the mine-run basis.

It was not until August 1, when this agreement was reached, that the mines were placed in operation. Cambridge and Massillon soon followed suit and before long all of the state, with the exception of eastern Ohio and Coshocton, was in operation. But the field still idle was by far the largest district of the state and comprised the counties of Belmont, Jefferson and Harrison. These counties in 1913 produced upward of 16,000,000 tons of coal.

Another factor appeared early in the year which tended to confuse the situation in the Buckeye State. This was the passage of the Ohio "Mine-run" law in February, 1914, which became effective in 90 days. Instead of using the old screen system, which had been in vogue for years,

[1] J. W. Lehman, *Coal Age*, Jan. 9, 1915, p. 53.

the law provided that the miners should be paid for all the coal mined, whether lump or slack.

This law was strongly opposed by the operators from all parts of the state. The miners' officials led by Senator William Green succeeded in having the law enacted, after a long struggle. The fact that it became operative soon after the expiration of the wage agreement tended still more to make it a difficult matter to settle the wage scale. Then, too, the demand was falling off, due to the business depression, and when the European war broke out, operators were not as anxious as formerly to concede anything in order to have the scale settled. This applies more particularly to the situation in eastern Ohio.

One of the results of the enactment of the mine-run law was that more attention is now given to preparation. Formerly, all Ohio operators made the grades of lump, ¾ in., nut and mine-run. In competition with West Virginia and Kentucky coals, it was evident that a larger lump found a better market, and some of the Ohio operators in rebuilding their tipples provided for a 3-in. lump. In some cases even 4-in. lump is made. The 3-in. product, commonly known as rescreened lump, sells for about 10 cts. more than coal prepared as formerly over a 1¼-in. screen.

With the enactment of the mine-run law came the necessity for rebuilding tipples in order that the legal method of weighing could be followed. During the suspension beginning April 1, many of the operators in Pomeroy Bend and the smaller districts rebuilt their tipples in order to weigh all of the coal produced before it was screened. Where the tipples had not been rebuilt, a temporary agreement was entered into between operators and miners for weighing the coal at different times, but mostly with the same scales. Several of the larger companies have put off the rebuilding of their tipples in the hope of having the mine-run law repealed at the coming session of the Ohio General Assembly. The cost of rebuilding tipples in Ohio is estimated at from $12,000 to $15,000 each wherever the tipples are too squatty for screening and must be made higher.

Throughout the strike, which has already lasted for 9 months in eastern Ohio and continued about 4 months in other districts, little violence on the part of the strikers took place. Some controversy occurred in certain parts of Belmont and Jefferson Counties over the employment of engineers and pumpers to keep the mines free from water. Several mobs were formed and in a number of cases duress was used to have the pumps abandoned. The Ohio mine department immediately got busy, and after calling the men together explained the consequences of their action. With the jailing of a number of the agitators of the Industrial Workers of the World, the violence ceased. On the other

hand, operators did not give the miners any cause for violence as they did not make any attempt to operate their mines with strike breakers, so called.

The lake trade in Ohio was about half or even less than half that of the previous year. There were two causes for this falling off in tonnage. One was the long suspension in the Hocking Valley and the total suspension in eastern Ohio, which is one of the large districts sharing in the lake trade. Only the larger operators in the Hocking Valley made any effort to ship lake coal, and when they got into the game boats had been chartered by other companies and additional bottoms were rather difficult to secure. Then, again, the docks of the Northwest became congested toward the latter part of the season and there was a marked falling off in lake tonnage in the latter part of October and during November.

Oregon.[1]—Only six mines were in operation in Coos County, Oregon, during the past year, and the output was light because the Southern Pacific Co. and C. A. Smith Co. concentrated their efforts on extensive development work in preparation for a large output on the completion of the Southern Pacific R. R. to Willamette Valley, where a good market for the coal will be afforded. Only 55,000 tons was produced in Coos County, and this tonnage is the lowest in years. The three largest mines are ready to multiply the output many times next year.

There are no mines or deposits worthy of mention in Oregon outside of Coos County, so the output of that area is practically the same as that of the state. Coos County has 450 sq. miles of coal land.

Pennsylvania.[2]—The coal production of Pennsylvania for the year 1914 will approximate 233,000,000 net tons, as against 264,000,000 in 1913. Of the total production, 148,000,000 tons was bituminous and about 85,000,000 tons anthracite.

The coal trade, in sympathy with all other industries, suffered somewhat from national legislation and the unsettled conditions produced by the European war. It is difficult to say which of these causes had the greater effect on the production.

As far as the anthracite production is concerned, the untoward influences had little effect, as the estimates for the year indicate a tonnage almost equal to that of 1913. This will be a surprise to many persons, but causes that may affect the bituminous trade have sometimes but little effect on the anthracite. More than this, the almost complete freedom from labor troubles in the latter region during the year permitted of practically uninterrupted operation, and no loss of production therefore resulted from this cause. The excessive drought, however, in some sections of the region interfered to a certain extent with the operations.

[1] Abstracted from *Coal Age*, Jan. 9, 1915, p. 54. [2] Frank Hall, *Coal Age*, Jan. 9, 1915, p. 54.

Just what effect will be felt in the future from the recent decision of the Public Service Commission in reducing freight rates on anthracite to Philadelphia it is difficult to forecast. The primary result of this action of the commission, as also of all legislative enactments affecting the industries of the country, is to unsettle trade and to a certain extent check its progress until adjustment to the changed conditions is accomplished.

The effect of the war on the bituminous trade has thus far been felt chiefly by the companies that furnish coal for the transatlantic steamers. Possibly the detriment suffered in this way may be more than compensated by increased exports.

The year has been remarkably free from serious accidents, and for the first time in many years the bituminous mines record fewer fatalities than the anthracite region. In fact, in the bituminous mines at no time during the year did an accident occur in which more than three persons were killed, a record almost without a parallel.

On the other hand, in the anthracite region there was a disaster in the 17th district in which six persons were killed by an explosion of gas, one in the 18th district by which six were killed by falling down a shaft, and one in the 3d district in which there were 13 fatalities, due to the dropping of the bottom of a cage on which men were descending. It was thought probable that one of the men being lowered accidentally dropped a stick of dynamite, causing an explosion that wrecked the cage. The cause of the accident, however, has not yet been determined. It marred what would have been an unusual record of freedom from casualties in the 3d district. Up to the time it occurred there had been only 17 fatal accidents reported, as against 24 in 1913 and 38 in 1912.

The strict enforcement of the mine laws by the Department of Mines and the issuance to the anthracite operators in December, 1913, of additional precautionary rules and suggestions relative to safety have no doubt lessened the dangers of mining operations. The inspectors report that the operators have with general unanimity put the rules and suggestions into practice, notwithstanding that to do so meant in many cases additional cost of operation. The rule requiring two daily inspections of every working place by the mine foreman or assistant mine foreman, in addition to the other inspections made under the law, has demonstrated its efficiency as a protection to the workmen. The other suggestions made at the time relative to accidents by falls, cars, blasts, explosions of gas, electricity and other causes are reported to have added to the safety of mining operations.

There were no serious labor troubles in the state, and strikes and suspensions were not of sufficient magnitude to affect the production in a marked degree. The general opinion among the inspectors and mining

men is that the coming year will show increased activity and consequently greater output.

A distinguishing feature of the coal-mining industry of Pennsylvania at present is the very evident improvement in the character of the buildings and accessories about the collieries and mines. Concrete and steel are rapidly superseding the combustible and more dangerous building materials used in the past.

The first-aid movement grows rapidly and the mines are nearly all provided with equipment and trained corps.

ESTIMATES OF BITUMINOUS AND ANTHRACITE PRODUCTION AND PERSONS EMPLOYED IN MINES DURING 1914

Districts.	Bituminous.			Anthracite.		
	Production (Net Tons).	Employees, Inside.	Employees, Outside.	Production (Net Tons).	Employees, Inside.	Employees, Outside.
First	3,225,000	4,848	801	2,688,000	4,160	1,550
Second	7,800,000	5,864	2,330	3,224,256	6,290	1,410
Third	2,100,000	4,714	682	3,673,360	5,922	1,704
Fourth	4,450,000	5,800	945	3,979,209	6,762	1,602
Fifth	5,200,000	3,400	2,200	4,088,000	5,200	1,500
Sixth	4,700,000	6,500	900	6,149,696	9,267	2,841
Seventh	6,000,000	6,200	1,250	2,988,720	4,502	925
Eighth	3,250,000	5,278	555	4,230,352	6,425	2,010
Ninth	6,250,000	4,500	2,250	6,773,916	8,028	2,241
Tenth	3,750,000	5,918	857	5,914,328	8,250	2,427
Eleventh	5,600,000	3,900	1,900	6,941,289	7,566	4,185
Twelfth	4,097,436	5,082	1,049	2,742,332	5,465	1,957
Thirteenth	3,675,000	4,100	400	3,371,110	4,164	2,715
Fourteenth	7,150,000	6,000	2,000	3,360,000	4,166	1,635
Fifteenth	4,800,000	6,000	700	2,867,760	4,641	2,068
Sixteenth	4,500,000	3,800	1,800	3,396,960	5,318	1,998
Seventeenth	4,424,164	5,216	573	5,491,202	6,713	2,975
Eighteenth	3,775,000	5,700	700	3,920,000	4,600	2,000
Nineteenth	6,750,000	5,930	825	3,662,604	5,229	2,596
Twentieth	6,300,000	6,200	800	2,409,120	4,560	1,595
Twenty-first	5,897,425	5,000	745	3,163,913	5,180	1,946
Twenty-second	4,500,000	5,900	770	.....	.....	.....
Twenty-third	4,800,000	3,300	1,900	.....	.....	.....
Twenty-fourth	4,500,000	5,500	500	.....	.....	.....
Twenty-fifth	4,500,000	6,200	1,250	.....	.....	.....
Twenty-sixth	5,181,000	5,910	850	.....	.....	.....
Twenty-seventh	4,500,000	4,100	490	.....	.....	.....
Twenty-eighth	4,313,327	5,600	534	.....	.....	.....
Totals	136,788,352	146,460	30,556	85,036,127	122,408	43,880

Tennessee.[1]—The past year has been one of unprecedented dullness in the coal business of Tennessee. The general inactivity of the coal market is partly due to the industrial depression but partly, also, it is a result of the open winter of last year which stagnated the market in the early part of the year, and also of the unusually warm weather this fall. This has seriously affected the local market for domestic coal on which many of our mines rely to a large extent.

While exact figures are not available, and an estimate under these

[1] Geo. E. Sylvester, *Coal Age*, Jan. 9, 1915, p. 56.

conditions is unsatisfactory, there was probably a reduction in this year's output of from 15 to 20 per cent.

Very few of the mines have been running regularly throughout the year, many having been, for considerable periods, running only a few days a week. There are, however, few mines which have been permanently closed, and there is no reason to believe that the decreased output tends to show any permanent decline in the industry, or that the state will not come back to its normal or an increased output under reasonably favorable conditions.

The mines have not become less safe and possibly have made some improvement in the last year. The use of permissible explosives is on the increase, most of our mines which would be classed as not at all dangerous using these explosives exclusively. The fatal-accident rate continues about the same and the mines of the state have not suffered from any severe disaster. This year has been free from labor troubles, and there has been little or no complaint of car shortage.

Although there seems to be no organized movement in "welfare" or "mine-safety work" among the operators, there has been much interest among the miners in "first-aid work." To this development the operators have, in most cases, given their hearty coöperation and support, and a successful field day was held in the fall under the management of the Society of Tennessee Mine Foremen.

Texas.[1]—The production of coal in 1914 fell far short of that in the previous year. This was owing to two factors, viz.: the financial depression due to the low price of cotton, and the cheapness of fuel oil, which enabled it to compete seriously with lignite. As a result, the mines have been working only about half time. The bituminous-coal trade has suffered less, though it also has been reduced by the industrial depression.

The production of bituminous coal for the year is estimated at about a million tons. The mine value of this output will approximate $2,500,000. The bituminous mines are located in Eastland, Maverick, Palo Pinto, Webb, Wise and Young Counties. The leading bituminous coal-mining companies are: Texas & Pacific Coal Co., Thurber; Strawn Coal Mining Co., Strawn; Wise County Coal Co., Bridgeport; Bridgeport Coal Co., Bridgeport; Belknap Coal Co., Newcastle.

The Texas & Pacific Coal Co. operates six mines, employs about 1800 miners and has a maximum daily production of about 2600 tons; the average thickness of the seam is 28 in. The long-wall method of mining is used except at the Newcastle mines. Union labor is exclusively em-

[1] I. J. Broman, *Coal Age*, Jan. 9, 1915, p. 56.

ployed in the bituminous field. There have been no labor troubles of an aggravated nature during the year.

The production of lignite for the year is approximately 700,000 tons, representing a valuation of about $1,000,000. There are 35 lignite mines scattered over an area approximating 50,000 sq. miles. These mines engage about 1600 men and none of them employ union labor.

The lignite mines are located in the counties of Bastrip, Hopkins, Lee, Houston, Leon, Medina, Milam, Rains, Robertson, Titus, Van Zandt and Wood. The largest and most productive mines are located in Wood County, and the one having the largest output in Texas produces 1000 tons per day.

The mines in Texas are unusually safe. The fatality rate for the year 1914 will not exceed one fatality for every thousand men employed. This excellent record is due in part to favorable natural conditions and to the control of the mines by operators.

Utah.[1]—The total output for the Utah mines for the fiscal year—Dec. 1, 1913, to Nov. 30, 1914—is 3,149,491 tons, showing a decrease in output from 1913 of 138,774 tons. The output of coke was 348,806 tons, or an increase of 34,112 tons. The mines worked approximately 196 days with 4348 men employed. There were no labor troubles during the year and two new coal properties have commenced shipping, namely, the Cameron Coal Co. and the Standard Coal Co. Two other companies have been organized, namely, the Chrystal Coal Co. and the Ketchum Coal Co.

The mines have not worked more than two-thirds of full time because of the general depression throughout the country caused by various industrial conditions. The copper mines of Bingham and the smelters in connection have worked but half force and consequently have used less coal than usual. Railroad traffic throughout Utah has been dull, the railroads using approximately 100,000 tons less than last year.

Moreover, the removal of the tariff from the Canadian and Australian coals has displaced much coal in the coast cities and contiguous territories. A total of 173 accidents was reported during the year, 20 of which were fatal and 24 serious. Five of the fatal accidents occurred on the surface, two as the result of a boiler explosion in the power plant of the Spring Canyon Coal Co. Considerable improvements have been made during the year in the mines of the old companies, and thus Utah is prepared to double the output of last year.

Mine Rescue Car No. 2 has made a trip through the various camps of the state and given instructions in first-aid and helmet work, which has been appreciated by all interested. One state contest in first-aid work and two local meets have been held during the past summer. The in-

[1] J. E. Pettit, *Coal Age*, Jan. 9, 1915, p. 57.

troduction of electric mining machines in Utah during the past 2 years has diminished the practice of shooting off the solid and also encouraged hand mining, with the following results: Coal mined by hand, 1,808,709 tons; mined by machines, 892,541 tons; shot from solid, 448,241 tons. There are 42 mining machines in operation.

Washington.[1]—Reports received for 11 months of the year indicate a decrease in the coal production of Washington for 1914. With the reports received and an estimate for December, the output for the year will be about 3,000,000 short tons, a decrease of over 850,000 tons compared with 1913. The output for that year was abnormal due to the strike in the coal mines of Vancouver Island, in British Columbia, about half a million tons of Washington coal being shipped to the British Columbia market.

Washington is the only state on the Pacific Coast that produces coal in any quantity. The production of coal in Washington has not increased as rapidly as the growth of the Pacific Coast States should warrant. In fact, the figures for 1914 will be about the same as 10 years ago. The production for the year 1914 is not very encouraging to the coal operators of Washington. In the past few years oil has replaced coal as a fuel in many of the manufacturing plants of the Pacific Coast States. Many of the steamers running out of Puget Sound ports are using fuel oil, which can be shipped from California at a very low cost. The railroads are also using large quantities of fuel oil—the Northern Pacific being the only railroad that uses coal exclusively. Electricity is also replacing coal in a great many cases. The natural resources of Washington enable the power companies to generate power at a very low cost to the consumer.

No labor troubles of any consequence occurred during the last year, except a few strikes of short duration which were settled with little loss of time.

Seventeen fatal accidents had occurred up to Dec. 19, against 22 for the previous year. Coal mining in Washington is a more hazardous occupation than in most of the Eastern and Central States, on account of the steep inclination of the beds. The pitch runs from 10° in some parts of the state to 80° in some of the mines in King and Pierce Counties. Accidents due to the pitch average about one-third of the total.

West Virginia.[2]—The output of coal for the calendar year just past will total about 71,700,000 short tons. The coke produced was about 1,425,000 tons. About 1,344,000 short tons of coal was used

[1] Jas. Bagley, *Coal Age*, Jan. 9, 1915, p. 57.
[2] Earl A. Henry, *Coal Age*, Jan. 9, 1915, p. 58.

in the operation of the mines; 896,000 tons was furnished to local trade and to tenants and 3,136,000 was used in coke ovens. About 67,200,000 was shipped from the mines and only 10 per cent. of this coal was consigned to points within the state.

Of the whole production, about 33,600,000 tons was produced by pick mining, at which roughly 20,000 persons were employed. The other 39,200,000 tons was mined by machine by 22,300 miners and 4300 machine runners and helpers. There were 18,300 other inside employees and 11,200 outside men exclusive of those employed around the coke ovens. These latter were tended by 1900 employees.

In all, 78,000 men were employed in and around the mines of the state, exclusive of foremen, office employees, store clerks, etc. Of these, 29,000 were foreigners and 49,000 Americans. About 10,000 acres of coal land were exhausted during the year. Roughly, 5500 mules were employed for haulage, 1000 horses and 1700 locomotives. Of these latter, 1600 were operated by electricity, 40 by air, 25 by gasoline and 50 by steam. There were about 600 generators in use and practically 1300 boilers.

From the figures rendered available by the companies' reports, there were 535,000 kegs of black blasting powder used and 3,800,000 lb. of permissible explosives, 297,300 kegs of powder and 1,400,000 lb. of permissibles being used in pick mining, while 237,700 kegs of powder and 2,400,000 lb. of permissibles were used in machine mining.

The tonnage for the past year has been reduced by about 1,500,000 gross tons on account of the strike which occurred in District No. 17 beginning June 1 and ending July 14, also by about 500,000 tons by strikes reported in other sections of the state.

There is, at the present time, sufficient development for an annual production of 100,000,000 gross tons from mines now in operation, and the reports indicate that there are at least 100 mines closed on account of the depression in business, also that at least 75 more are in the early stages of development and will be able to produce a considerable tonnage within the next year.

During the last year there have been about 20 new fans installed, 30 new tipples constructed, 600 new mine cars purchased, 30 new locomotives installed and 400 new dwellings built.

The production of coke for the last year shows a decrease of practically 1,000,000 net tons, and owing to the many modern changes in coke production, also the many conditions adverse to its production in this state, still further decrease is expected in this production in the next year, as only about 40 new ovens were constructed last year while about 300 have been abandoned.

These figures, of course, are not final but are based on information available at this time. They are, however, reasonably accurate, and the changes to be made when final reports are obtained will be immaterial.

Coal in Foreign Countries

Africa.—The coal industry in South Africa has never been considered a profitable investment. Local capital is interested almost exclusively, and scarcely, if ever, have any dividends been paid. The gross coal sold in the Union of South Africa in 1914 amounted to 8,477,923 tons, as compared with 8,801,216 tons in 1913. That the war had an important effect upon the output of coal is evident by the sharp decline in the production of Natal during the closing months of the year, due no doubt to the slowing down in the demand for bunker coal. The output of Transvaal, which is the largest producer in the Union, was 5,157,268 tons in 1914, as compared with 5,225,036 tons in 1913.

COAL PRODUCTION IN THE CHIEF COUNTRIES OF THE WORLD.
(In metric tons.)

Countries.	1910.	1911.	1912.	1913.	1914.
Asia:					
China	(e)13,190,000	(e)13,000,000	(e)13,000,000	(e)14,000,000	(e) 9,272,000
India	12,240,744	12,715,534	14,951,445	14,946,985	16,478,142
Japan	15,681,324	17,632,710	19,515,285	.....	19,686,630
Australasia:					
New South Wales	8,309,733	8,836,464	10,050,579	10,587,734	.....
New Zealand	2,210,546	2,100,508	2,177,615	1,919,472	.....
Other Australia	1,611,921	1,889,498	1,874,693	2,024,062	.....
Europe:					
Austria Hungary(c)	47,943,109	49,859,655	52,521,776	54,112,272	41,460,000
Belgium	23,916,560	23,053,540	22,972,740	22,858,000	.....
France	38,349,942	39,229,591	41,308,580	40,050,888	.....
Germany	222,375,076	234,521,254	255,810,094	191,511,154	161,535,224
Italy	562,153	557,137	663,812	701,081	.....
Russia	24,026,000	28,007,239	30,641,163	32,206,000	33,113,000
Spain	4,057,532	3,915,672	3,126,006	(c)4,292,522	3,600,000
Sweden	302,786	311,809	360,291	363,965	.....
United Kingdom	268,676,528	276,332,960	257,136,000	292,047,544	270,070,414
North America:					
Canada—					
Western	6,446,336	5,500,000	6,684,161	6,381,221	5,677,127
Eastern	6,564,930	6,602,000	8,801,216	7,241,446	6,659,519
Mexico	2,450,000	.....	2,450,000	.....	.....
United States	445,816,040	455,720,550	534,466,580	517,285,050	.....
South Africa (a)	6,508,383	7,045,805	7,365,770	8,801,216	8,447,932
Other Countries (f)	.....	5,000,000	5,000,000	5,000,000	5,000,000
Totals	1,151,239,643	1,191,831,926	1,290,877,806	1,226,330,612	.....

(a) Transvaal, Natal and Cape of Good Hope. (c) Includes lignite. (e) Estimated. (f) Includes a part of Finland.

Exports for 1913 amounted to 856,031 tons and the coal used for bunkering purposes was 1,451,751 tons, showing a slight increase over 1912. Most of the exports are to East African ports, although India and Ceylon take about 36 per cent. of the total exports.

Conditions in the Natal industry were greatly improved during 1913

through the formation of the Coal Owners Association to regulate the price of coal. Previous to this time there has been a very sharp competition, and companies producing high-grade coal have found it exceedingly difficult to realize a profitable figure. Higher prices are now being obtained, and although the increased profits have generally been reinvested in improving the collieries, it is anticipated that many of the companies will shortly be able to start paying dividends.

Austria-Hungary.—The Austrian coal production suffered a decline of about 9 per cent. in 1914 as a result of the war and a shortage of railroad cars. The total output was: Coal, 15,073,000 tons; coke, 2,190,000 tons; lignite, 23,772,000 tons; coal briquettes, 194,000 tons; lignite briquettes, 231,000 tons. The figures for Hungary are much slower in being issued, the latest available at this date being for 1912, in which year the output was: 1,079,096 tons of coal, 8,131,307 tons of lignite, 149,912 tons of coke, and 118,505 tons of briquettes.

The Austrian output originates principally in the state of Ostrau-Karwis, which in 1914 produced 8,917,922 tons of coal, 2,119,990 tons of coke, and 30,432 tons of briquettes. The other producing states in the order of their importance, together with their output of coal for 1914, were: Kladno, 2,439,337 tons; Pilsen, 1,159,087 tons; Galicia, 1,399,961 tons; other districts, 1,156,825 tons.

The exports of coal from Austria in 1913 amounted to 708,975 tons, lignite 7,016,606 tons, and coke 369,802 tons. The imports for 1913 amounted to 13,689,149 tons, as compared with 11,848,535 tons in 1912. Of the total coal import, 12,748,021 tons originated in Germany in 1913.

Australia.—The tonnage of coal dumped over the government piers at Newcastle in 1914 amounted to 5,318,906 tons, or practically the same as in 1913. This figure includes the coal loaded for use within the state, as well as for exporting. The production of New South Wales in 1913 amounted to 10,414,165 tons, as compared with 10,390,622 tons in 1914. Conditions in this district were generally favorable through most of the year, though there were occasional labor disputes that interrupted the production. The coke production in this state was fairly brisk until August, after which it was much curtailed.

In Western Australia there were six mines working during 1913 which produced 313,818 tons, or about 19,000 more than in 1912. The increased production is ascribed more particularly to improved machinery and better equipment. At the Victorian State mine the production in 1914 amounted to 510,490 tons of mine-run coal. The production of coal in the province of Victoria for 1913 showed a slight increase, being 593,912 tons, valued at £274,371. This coal is produced almost entirely from the state mine at Worthaggi.

A recent report of the director of the Geological Survey discloses some interesting points regarding the coal measures, superior beds of coal 100 ft. thick being described in several different districts.

The gross coal exports for the year fell off nearly half a million tons, being only 4,753,505 tons; this reduction was mostly in the shipments to New Zealand.

Canada.—The Canadian coal industry was less active in 1914 than in the preceding year, particularly in Alberta and British Columbia. The lack of demand due to the general depression noticeable in the early part of the year, and very much accentuated when war was declared, was responsible for the curtailed activity. One of the principal developments of the year was the closing down of the large mine owned by the Canadian Pacific Ry. at Hosmer, British Columbia. It is estimated that about $1,000,000 had been invested in this operation, the results of which had not been satisfactory. The strike of the coal miners on Vancouver Island, which had been in effect for about 2 years, was brought to a close during the year, when the mine workers' organization discontinued the payment of strike benefits.

The gross output of marketable coal in 1914 amounted to 13,594,984 tons, as compared with 15,012,178 tons in 1913 and 14,512,829 tons in 1912. Nova Scotia continued far in the lead among the producing provinces, her output for the year being 7,338,790 tons, with Alberta second, having a production of 3,667,816 tons; British Columbia ranks third with 2,238,339 tons, the remaining provinces all producing less than a quarter of a million tons per annum.

The exports in 1914 amounted to 1,423,126 tons, as compared with 1,562,020 tons in 1913. The imports of bituminous mine-run coal in 1914 declined about 28 per cent., being only 7,776,415 tons, and slack imports fell off about 11 per cent., the total for the year being 2,509,632 tons. The apparent consumption of coal was substantially less than in 1913, the respective figures being 26,809,778 tons in 1914 and 31,582,545 tons the year before. About 45 per cent. of the 1914 consumption was of domestic coal.

The output of coke fell off heavily, declining from 1,517,133 tons in 1913 to 1,015,253 tons in 1914. Coke is produced principally in Nova Scotia, Ontario and British Columbia, the Ontario coke being manufactured from imported coal almost entirely. At the close of the year there were only 797 ovens in operation, against 2297 idle.

China.—The coal output of the main producing districts in China in 1914, according to the Ministry of Agriculture and Commerce at Peking, amounted to 9,272,000 tons. Of this amount the province of Shansi produced 2,500,000 tons and Chihli 2,160,000 tons. Most of the coal in the

Chihli Province is produced by the Kailan Mining Administration, their gross output in 1913 being 2,036,966 tons, as compared with 1,706,658 tons in 1912. This company has recently contracted for the erection of coke ovens at Tungshan. Other provinces produced as follows: Shantung, 932,000; Hwnan, 900,000; Manchuria, 840,000; Kiangsi, 800,000; Hunan, 500,000; Ssuchwan, 300,000; Hupeh, 100,000; Anhwei, 60,000; Shensi, 50,000; Kwantung, 50,000; Kansu, 50,000; Yunnan, 30,000 tons. These figures are in all probability too low; several provinces which produce coal are not listed.

The Peking Syndicate, which has been engaged in a dispute with the people of Honan as to rights and boundaries, has finally made an agreement with the representatives of the people. There is general interest in coal mining, and many hundred permits have been issued to native companies by the Bureau of Mines. Production keeps abreast of consumption, but the lack of transportation facilities hampers the coal industry, while the lack of good harbors on the China coast is a severe handicap to the export trade.

The coal trade at Hong Kong in 1914 showed a substantial increase over that for the preceding year. The total imports at this port in 1914 amounted to 1,613,111 tons, as compared with 1,487,750 tons in 1913 and 1,239,144 tons the year before. Most of these imports come from Japan, the gross for 1914 amounting to 1,007,984 tons, or about 62 per cent. of the total. The exports in 1913 amounted to 1,500,000 tons, or about double that in 1912. This tremendous increase is due more or less directly to the development of the Kailan project, a British-Chinese enterprise, with about $10,000,000 capital, operating mines in the Kaiping and Lanchow district.

Egypt.—The Egyptian imports of coal during the first half of 1914 amounted to 921,343 tons, as compared with 814,146 tons during the same period in 1913 and 685,557 tons in 1912.

Germany.—In common with other European countries, the German output of coal suffered a heavy decline during the closing months of 1914, which pulled the gross tonnage down considerably below normal. The Westphalian Coal Syndicate, through which most of the product of the country is handled, showed a production for the year of 84,819,000 metric tons, as compared with 101,652,000 tons the preceding year. In 1913 the non-syndicated collieries produced 11.12 per cent. of the total output, but this was increased to 13.52 per cent. in 1914; in contrast with the syndicated collieries these others showed an increase of about 565,000 tons, the gross output for the year being 13,300,000 tons. The coke production also showed an increase of 200,030 tons, the gross for 1914 being 3,840,000 tons, or about 5.72 per cent. greater.

The total production for all mines was: coal, 161, 535,000 tons, as compared with 191,511,154 tons in 1913; lignite, 83,946,911 tons; coke 27,324,712 tons; coal briquettes, 5,948,929 tons; lignite briquettes 21,388,900 tons.

Evidence of the abnormal conditions prevailing during the mobilization of the German army is seen in the production of the Coal Syndicate for August, which amounted to only 2,545,936 tons; but when railway equipment was again released for general use, the following month the output increased to 5,509,528 tons and continued to show a slow improvement throughout the balance of the year. None of the companies included in the Snydicate was able to show any profits during the third quarter, but in the last quarter dividend distributions were again resumed, and with the large demand for coal a gradual improvement is to be expected through 1915.

Though the German fuel exports for 1914 are not available at this time, it is safe to assume that they showed a heavy loss. The German exports have made a very consistent and rapid increase over a number of years, due to the very excellent preparation and well-known aggressiveness of the Germans in foreign trade. Thus, the coal exports amounted to 34,500,000 tons in 1913, showing an increase of 3,500,000 tons over the previous year. Austria-Hungary is the largest importer of German coal, taking about 12,000,000 tons in 1913, Holland being next with 7,000,000 tons, Belgium, 6,000,000, and France, 3,000,000.

Great Britain.—Previous to the outbreak of the war, the coal industry of Great Britain had experienced a comparatively quiet year with few periods of appreciable activity. The outlook at the beginning of the year had not been particularly encouraging. A gradual decline had characterized the closing period of 1913 and a continuation of this moderately depressed condition was anticipated, and in fact realized, during the early part of 1914. As was to be expected, the output showed a heavy decline, the gross for the year being 297,520,193 tons, as compared with 321,901,293 tons for the preceding year.

The early spring period brought with it a strike of small proportions on the part of the Yorkshire miners, which resulted in some temporarily high prices on coal from that district, as did also another labor dispute in Scotland about mid-year, when the operators endeavored to reduce the wage scale. This latter trouble was lost sight of, however, in the complete demoralization which resulted with the declaration of war in the early days of August.

The abnormal conditions precipitated by the war formed the most interesting phase of the British coal industry for the year. The government immediately declared a general embargo against the exportation of

steam coal, though this was soon modified to cover only the enemy countries; it was provided, however, that shippers must furnish a bond for three times the value of the cargo, which was to be held pending authoritative proof of the delivery of the shipment to its proper destination. Operators found themselves unable to meet this condition, with a result that export shipments ceased entirely until the bond was removed on Aug. 19. But in the meantime other complications had developed, such as the declaration of a moratorium, so that sales were difficult to arrange and the collieries shipping the export trade were, for a time, heavy losers.

But even in the face of these extremely adverse conditions during the close of the year, Great Britain successfully maintained her position as the leading exporter of fuel, though the tonnage was substantially under that for 1913, the comparative figures for the year being 61,830,485 tons in 1914, against 76,687,241 tons in 1913, these figures including coal, coke and manufactured fuel. Practically the whole of this loss was confined to the last half of the year. The shipments for the first quarter were about five million tons less in 1914 than in 1913, and slightly more than eight million tons less during the fourth quarter. The gross loss in export tonnage, including bunker coal, in 1914, as compared with the preceding year, amounted to 17,353,000 tons.

Export prices in 1914, although higher to the consumer, due to the abnormal conditions prevailing in shipping, were substantially less, f.o.b., than in 1913. During the last half of 1914 the average value per ton ranged from 13s. 2d. to 13s. 5d., the average for the year being 13s. 7d. as compared with 14s. for the entire year of 1913.

France continued the leader among the importers of British coal, taking about 12,300,000 tons in 1914, which is only about half a million tons less than 1913 and considerably more than in 1912. The exports to Italy amounted to only a little more than 8,500,000 tons, showing a loss of more than a full million over 1913. German imports of British coal of course suffered a heavy decline, falling from close to 9,000,000 tons in 1913 to only about 5,250,000 in 1914. Exports to Russia also suffered heavily in 1914, being only about 3,000,000 tons, as compared with 6,000,000 the preceding year.

Holland.—Coal imports into Holland fell off from 13,710,219 tons in 1913 to 11,276,526 tons in 1914. Germany has by far the larger amount of this trade, furnishing 9,400,654 tons in 1914, as compared with 1,716,090 tons from Great Britain and 159,782 tons from Belgium. The German tonnage for the year showed a decline of 2,036,000 tons, while Great Britain lost 287,000 tons and Belgium 110,000 tons. The loss in imports, however, was largely counterbalanced by a reduction

in exports, which show a decrease of 1,400,000 tons, most of which goes to Belgium and the remainder to Germany and France.

India.—The output of coal in India for the fiscal year ended Mar. 31, 1914, amounted to 16,208,009 tons, as compared with 14,706,339 tons for the same period to Mar. 31, 1913, and 12,715,534 tons in 1912. Although the output showed a substantial increase, the industry suffered considerably from abnormal floods, fires and scarcity of labor, together with a shortage of railroad cars.

Exports for the year declined from 881,239 tons for the fiscal period of 1913 to 723,641 tons in 1914. More than one-half of the exports go to Ceylon and the balance to Straits, New Zealand, Sumatra and Aden. Practically all the exports are through Calcutta, at which point 1,010,074 tons was also loaded for bunkering purposes. The imports for the fiscal period of 1914 amounted to 559,190 tons, as compared with 653,694 tons in 1913 and 297,912 tons the preceding period.

In Sumatra, the government coal mine at Ombiliem produced 440,905 tons during 1914. About 85 per cent. of the total Indian output originates in the Ranitanj and Jheria field.

Italy.—With the outbreak of the war, Italy was brought face to face with a serious problem in its fuel supply. Coal is obtained almost entirely from Great Britain and Germany. The British imports for 1914 fell off more than a million tons, being only 8,625,000 tons in 1914, as compared with 9,647,000 tons in 1913; the German imports declined from 1,073,000 tons in 1912 to 819,000 tons in 1914.

The German imports arrive by way of the St. Gothard Ry. and in August shipments ceased almost entirely, though they were again resumed in September and showed a steady increase throughout the balance of the year, amounting to 48,000 tons in December. Reviewing the Italian coal imports back over a period of 5 years, they show only a comparatively small increase. In the year 1912 it was estimated that the railways consumed about one-fourth of the entire requirements.

Japan.—Although the Japanese exports have shown a very consistent increase for a number of years, 1914 failed to come up to the 1913 record by about 300,000 tons, the respective figures being 3,840,000 tons in 1913, as compared with 3,558,000 in 1914. On the other hand, the imports show an unusually large increase, from 552,000 tons in 1913 to 950,000 tons in 1914. The production for 1914 is reported as follows: Muke, 2,226,700 short tons; Tagawa (Mitsui's), 1,092,285; Onoura, 880,000; Yubari, 774,400; Minenoike, 737,250; Futase, 660,500; Iriyana, 596,300; Yoshinotani, 575,000; Meiji, 550,700; Hokoku, 537,000; Namazuta, 522,000; Shinnyu, 468,500; Tadakuma, 454,100; Shiozumeo, 449,300; Yamano (Mitsui's), 446,000; Uchigo, 416,100; Aichi, 404,000; Kanada,

366,400; Shin-Yubari, 364,900; Matsushima, 351,000; Hondo (Mitsui's), 346,260; Koma, 343,400; and 59 other collieries producing less than 333,000 tons each, 8,099,115; making a total of 21,695,071 tons.

Russia.—The production of coal in the Donetz basin for 1914 amounted to 27,630,000 tons, as compared with 24,900,000 tons in 1913; this includes anthracite, the output of which was 5,000,000 tons in 1914 and 4,686,000 tons in 1913. In 1914 there were 181,000 men engaged in the coal industry, as compared with 168,000 in 1913. This number fell off very considerably during August, but again increased in November and reached a total of 208,000 in December. The gross output for all districts was 33,240,000 tons.

Russian imports into Finland in 1913 amounted to 537,000 tons, as compared with 488,000 tons in 1912; practically all of the imports are from Great Britain. For the first 9 months of 1914 the total Russian imports amounted to 4,299,000 tons, as compared with 5,047,000 tons for 1913.

Spain.—Coal is raised in seven different provinces of Spain and the aggregate production is about 3,600,000 tons. The province of Oviedo produces about 2,373,000 tons, other producing districts in the order of their importance being Cordova, Diudead Real, Leon, Sevilla, Palentia, and Gerona. The Spanish imports for 1914 amounted to 2,504,985 tons of coal, as compared with 2,707,913 tons in 1913, and 370,768 tons of coke in 1914, against 396,419 tons in 1913.

South America.—Importations of coal into Peru in 1913 amounted to 150,660 tons, of which Great Britain supplied 78,958 tons, the United States 11,461 tons, Germany 32,696 tons, and Australia, Chile, Netherlands, and Belgium smaller amounts. The long-established trade connections with Great Britain give the English importers a decided advantage in this trade. However, it is anticipated that the opening of the Panama Canal will give the American operators a better opportunity, which will no doubt be accentuated by the European war.

Imports of coal into Argentina for 1913 amounted to 4,046,278 tons, as compared with 3,707,956 tons in 1912; coke imports in 1913 amounted to 21,317 tons, as against 31,088 tons in 1912.

The imports of coal into Brazil in 1914 amounted to 1,540,126 tons, which shows a heavy decline from the figures for 1913, when the total was 2,262,347 tons. More than half of the Brazilian coal imports arrive at Rio de Janeiro.

Spitzbergen.—Coal exports from this district in 1912 amounted to 40,000 tons, and have been somewhat increased since then as the mines have been further developed. A number of different countries are interested in this section, but the Americans have so far made the greatest developments.

COPPER

By F. F. Hintze, Jr.

The copper industry of the world during 1914 failed to reach the 1,000,000-ton mark which was somewhat exceeded during the preceding 2 years, and fell back to a level of production slightly below that of 1909, with a decrease of about 7.5 per cent., as compared with figures for 1913. The American rate of production for 1913 continued for the first 7 months of the past year with some increase, but with the beginning of the European war, which interfered at once with the foreign consumption, and especially that of Germany, which is one of the largest importers of copper, came a marked curtailment in output. The final figures for the year, however, are better than had been expected from the reported 50 per cent. decrease of production by the chief concerns, following the outbreak of the war. This cut of one-half was based on the rate of production in July, which was considerably above the average for 1913, so that the total production for the year fell but moderately below that of the preceding year. Had there been no curtailment from unforeseen causes, such as those imposed by the war, 1914 would have been the banner year for copper.

Since 1903 the United States has furnished over half of the world's output of copper, the percentage for 1914 being 56.4, as compared with 55.3 per cent. in 1913.

These figures indicate a relative increase for the United States over the combined production of all other countries during the past year, the decrease in the total production being borne largely by foreign states. Of this decrease, the United States has suffered to the amount of 44 per cent. whereas other countries contributed to the extent of 56 per cent. These comparative results may be otherwise stated, as follows: of the total decrease in world production of 7.5 per cent., 3.3 per cent. was borne by the United States and 4.2 per cent. by the other countries. This amounts to a decrease in production during 1914 of 7.3 per cent. for this country, as against 11.5 per cent. for other countries, as compared with the output of the preceding year. When thus combined with the high production figures of the first half of the year the actual curtailment of production appears to be small, but when the output of the last half of the year is considered separately the great reduction in the rate of production becomes more apparent.

In the following table the normal monthly output of more than 20 of the leading copper producers may be compared directly with the curtailed production of each company for 3 months, beginning August 1, 1914.[1]

Mines or Group.	Output Reduced, Per Cent.	Normal Monthly Output, Lb.	Curtailment 3 Months, Lb.
Anaconda	50	20,000,000	30,000,000
Utah Copper Co.	50	13,200,000	19,800,000
Ray Con	50	6,200,000	9,300,000
Chino	50	5,000,000	8,700,000
Nevada Con.	50	4,800,000	7,200,000
Miami	50	3,200,000	4,800,000
Greene-Cananea	100	3,500,000	10,500,000
East Butte	100	1,250,000	3,750,000
North Butte[2]	50	2,300,000	5,200,000
Calumet & Arizona	50	5,700,000	8,400,000
Shattuck	50	1,200,000	1,800,000
Phelps-Dodge	25	12,000,000	9,000,000
Old Dominion	25	1,000,000	2,250,000
United Verde	33	3,000,000	3,000,000
Tamarack	100	500,000	1,500,000
Tennessee	33	1,500,000	1,500,000
U. S. Smelting Co.	50	1,700,000	2,500,000
Mountain	100	750,000	2,250,000
Granby	50	3,300,000	4,950,000
Calumet & Hecla	20	10,000,000	6,000,000
Copper Range	50	4,000,000	6,000,000
Quincy	50	2,000,000	3,000,000
Miscellaneous and imports	.....	30,000,000	15,000,000
Total	.....	138,900,000	166,400,000

The departure from the normal output amounts to an average of 40 per cent. for the companies listed, which is evidently somewhat too high a figure to be used as the curtailment factor for the whole of the last half year. The percentage of reduction in the case of many important producers did not become effective at once, and the high rate of production during the first 6 months of the year also tended to minimize the effect of the curtailment policy on the total production for the year. However, as an index to the probable output of the coming year, providing present conditions continue, the above curtailment factor of 40 per cent. may not be much too great.

The smelter production from American and imported ores and scrap during 1914 amounted to 1,398,484,346 lb. of copper as, compared with 1,516,796,972 lb. for 1913. Nearly all of this crude copper went to American refineries along with 131,125,076 lb. of imported crude copper, so that the refiners received a total of 1,492,843,502 lb. from all sources. The following table shows the smelters' production for the past 4 years, together with the deliveries to American refineries during that period:

[1] *Min. Eng. World*, Nov. 14, 1914.
[2] Closed for 6 weeks; then operating 50 per cent.

SMELTERS' PRODUCTION
(In pounds)

Source.	1911.	1912.	1913.	1914.
N. American ore	1,284,932,019	1,489,176,562	1,438,565,881	1,327,488,479
Foreign ore	34,392,091	53,701,307	55,803,202	50,101,308
Scrap	18,529,547	11,949,348	22,427,889	20,894,559
Totals	1,337,853,657	1,554,827,217	1,516,796,972	1,398,484,346
To foreign refiners	32,413,440	45,735,673	36,682,605	36,765,920
To American refiners	1,305,440,217	1,509,091,544	1,480,114,367	1,361,718,426
Crude copper imported	146,422,851	144,480,144	169,315,869	131,125,076
Total crude copper	1,451,863,068	1,653,471,688	1,649,430,236	1,492,843,502

The copper production of the several states for the last 6 years is given in the following table:[1]

COPPER PRODUCTION OF THE UNITED STATES
(In pounds)

State.	1909.	1910.	1911.	1912.	1913.	1914.
Alaska	4,057,142	5,008,171	19,412,000	32,602,000	24,452,000	24,288,000
Arizona	292,042,829	299,606,971	300,578,816	357,952,962	399,849,745	387,978,852
California	53,357,451	45,793,894	36,806,762	31,069,029	32,390,272	29,515,488
Colorado	10,487,940	10,127,012	8,474,848	7,502,000	7,670,090	10,104,579
Idaho	7,770,010	6,216,461	3,745,210	5,964,542	8,434,028	4,856,460
Michigan	227,247,998	221,400,864	216,412,867	231,628,486	159,437,262	157,089,795
Montana	313,838,203	286,242,403	271,963,769	309,247,735	285,336,153	243,139,737
Nevada	51,835,309	63,877,500	65,385,728	82,530,608	84,683,961	60,078,095
New Mexico	5,134,506	3,632,351	1,518,288	27,488,912	46,953,414	64,338,892
Utah	100,438,543	125,042,381	138,336,905	131,673,803	147,591,955	153,555,902
Wyoming	89,654	180,861	.....	1,121,109	448,805	165,023
Southern States	22,837,962	18,195,450	19,656,971	18,592,655	24,333,014	19,213,965
Other States	3,746,895	925,664	1,564,207	4,396,667	4,155,135	4,257,088
Total	1,092,884,442	1,086,249,983	1,083,856,371	1,241,770,508	1,225,735,834	1,092,884,442

The diminished output for the year 1914 was borne in part by all of the states, with the exception of Utah, which shows a slight gain over the output of the previous year. Arizona continued to hold first place in production, with Montana, Michigan, and Utah following in descending order. In all of these states a marked increase for the year would have been realized had it not been for the curtailment which became necessary in consequence of the business depression resulting from the war. In the case of Utah the increase during the first half of the year was more than sufficient to compensate for the curtailed production during the latter part of the year, with a small increase for the year. Michigan was just recovering from the effects of the protracted labor troubles which menaced her mining operations so seriously during the previous year, when she was again hampered by the crumbling of the copper market and general stagnation of business resulting from the European war. Montana's produc-

[1] *Eng. Min. Jour.*, Jan. 9, 1915.

tion was the smallest for several years in spite of the hopeful outlook at the opening of 1914. Labor difficulties between two factions of the miners' union broke out before the middle of the year and caused the first decrease in output, but as the effects of the war began to be felt throughout the country all of the operating companies at Butte curtailed their production to the extent of 50 per cent., so that for the last 5 months of the year the state's production was practically one-half that of the first 6 months of the year.

The fifth greatest copper-producing state in 1914 was New Mexico, Nevada coming sixth. Notwithstanding the war and the curtailment of production which was also felt in New Mexico, that state showed an increase for the year of about 35 per cent., due chiefly to the large-scale operations of the Chino Copper Co., at Santa Rita. Nevada had an exceedingly poor year, showing a decline of almost 25,000,000 lb. in production, brought on chiefly by the curtailment during the latter half of the year as a result of the war.

The reports of the American smelters give the production of copper for the copper-producing countries of North America during 1914 as follows:

SMELTERS' PRODUCTION OF COPPER IN NORTH AMERICA
(In pounds)

Country.	1911.	1912.	1913.	1914.
United States	1,083,856,371	1,241,770,508	1,225,735,834	1,158,581,876
Canada	56,370,754	75,425,575	76,796,586	75,015,758
Mexico	136,430,331	162,295,545	128,579,656	80,108,165
Cuba	8,274,563	9,684,934	7,453,805	13,782,680
Totals	1,284,932,019	1,489,176,562	1,438,565,881	1,327,488,479

The output of Mexico has suffered a further reduction of nearly 40 per cent. as a combined result of the European war and the continuation of the revolution. Since 1912 the copper production of Mexico has fallen off over 50 per cent. At first the industry was affected by internal conditions and a marked decline in production was the direct result of internal warfare, and though the last year has not seen the restoration of proper conditions for the resumption of normal production, the failure of the copper market during the latter half of the year is probably responsible for a large part of the 40 per cent. diminution of last year's output.

The total production of new refined copper in 1914[1] was 1,533,781,394 lb., of which 323,358,205 lb. was produced from foreign, and 1,210,423,189 lb. from domestic, sources.[2] There was also produced during the year from secondary sources 31,926,980 lb. of refined copper, making a total

[1] Advance statement, U. S. Geol. Surv.
[2] The distribution of refined copper of domestic and foreign origin is merely approximate.

of 1,565,708,374 lb. of refined products for the year. The production of refined copper according to class for the last few years is shown in the following table.[1]

PRODUCTION OF COPPER IN UNITED STATES ACCORDING TO CLASS
(In pounds)

Year.	Lake.	Electrolytic. (d)	Casting. (d)	Pig Copper. (a)	Total.
1907....	220,317,041	854,441,000	47,957,890	30,032,000	1,152,747,931
1908....	222,267,444	850,660,325	44,967,250	35,000,000	1,152,895,019
1909(e)..	226,602,134	1,101,518,458	67,471,446	43,159,018	1,438,751,056
1910(f)..	221,400,864	1,151,624,597	(g)55,673,196	46,903,463	(g)1,475,602,120
1911....	216,412,867	1,156,627,311	22,977,534	35,920,626	1,431,938,338
1912....	231,628,486	1,288,333,298	24,777,266	37,181,237	1,581,920,287
1913(b)..	155,715,286	1,037,360,178	44,966,222	36,004,986	1,652,290,541
1914(b)..	158,009,748	1,019,276,001	25,730,377	39,334,043	1,565,708,374

(a) Exported. (b) Advance statement, U. S. Geol. Surv. (c) Partly estimated. (d) Included copper from scrap and junk. (e) The statistics for 1909 are officially communicated to us by the Copper Producers' Association, except that to its report of 34,123,446 lb. of casting copper we have added 33,348,000 lb. reported to us by the junk smelters. The term "Lake" copper is here used to designate all copper sold in the trade as such, regardless of the process by which it is refined. (f) Copper Producers' Association, through *Eng. Min. Jour.*, May 6, 1911. (g) Includes 23,480,000 lb. from scrap.

In addition to the secondary material treated by the regular refining companies, plants that treated secondary material exclusively produced a total of 224 million lb. of copper in the form of brass and other alloys, making a total production of approximately 256 million lb. from secondary sources. Of this material at least 80 million lb. was produced by remelting clean scrap produced in the process of manufacture of copper and brass articles. If the output of plants producing only secondary material is added to the production of the regular refineries, the contribution of domestic plants of the United States to the world's supply of copper for 1914 is found to be 1789 million lb.

Consumption.—The following tabulation gives the estimated consumption of copper in the principal countries of the world during the 3 years preceding 1914.

The Copper Producers' Association suspended the publication of its valuable monthly statistics on copper at the outbreak of the war, and on January 13, 1915, voted to discontinue its organization. This action is much to be regretted as the accurate statistics of the Association have formed the most complete summary of production, refiners' output, and exports of copper in this country during the 5 years of that organization's existence. From the data given in the table the visible supply of copper in the hands of the producers from month to month was known to the consumers, and was a valuable gauge to the producers themselves in regulating the output so as not to overstock the market. Had the consumers furnished a set of figures each month indicating their stocks of

[1] Owing to some uncertainty as to the counting of copper regained from scrap it is unsafe to draw fine deductions from this table.

raw material the rate of production could have been absolutely controlled to suit the demand. Even without the consumers' data the benefits to the copper industry of the concerted action on the part of the producers are clearly indicated by the way the extremely difficult situation resulting from the war was handled whereby an impending crisis was quickly avoided.

WORLD'S CONSUMPTION OF COPPER
(Metric tons)
(From statistical report of the Metallgesellschaft, Frankfurt am Main)

Europe.	1911.	1912.	1913.
Germany	222,500	231,700	259,300
Great Britain	159,100	144,700	140,300
France	95,700	98,500	103,600
Austria-Hungary	38,500	48,200	39,200
Russia	32,800	40,000	40,200
Italy	29,400	34,200	31,200
Belgium	13,500	15,000	15,000
Netherlands	1,000	1,000	1,000
Other European countries	10,000	10,200	(a)13,300
Total consumption in Europe	602,500	623,500	643,100
America			
United States	321,900	371,800	348,100
Others in America	3,000	3,000	3,000
Total consumption in America	324,900	374,800	351,100
Asia, Australia, Africa			
Production Japan and Australia	95,000	111,900	119,000
Imports from Europe	500	1,400	1,000
Imports from America	.....	500	80
Total	95,500	113,800	120,100
Exports to Europe and America	68,800	74,300	69,800
Consumption in Asia, Australia and Africa	26,700	40,400	50,300
World's consumption	954,100	1,038,700	1,044,500
World's production	893,800	1,018,600	1,005,900

(a) Estimated.

The following table gives the figures of the Copper Producers' Association, together with those of Henry R. Merton & Co. relating to production, deliveries for domestic consumption and foreign use, and visible stocks in the United States and Europe, as far as they have been issued by the respective organizations for the years 1913 and 1914.

The domestic supply of salable copper on Jan. 1, 1914, was 91,438,867 lb. and the stocks of refined copper on hand at the plants of the refineries on Jan. 1, 1915, was 173,640,501 lb.[1] The production of refined copper during 1914 was 1,565,708,374 lb., which, combined with the domestic supply at the beginning of the year, makes an available supply of 1,657,147,241 lb. for the year. This compares with 1,727,763,411 lb. for 1913. During 1914 there was exported 840,080,922 lb. of all classes of refined copper, which, subtracted from the total available supply, leaves 817,066,319 lb. on hand for home consumption. After deducting the supply on

[1] Advance statement, U. S. Geol. Surv.

hand Jan. 1, 1915 from the domestic supply, the apparent home consumption amounted to 643,425,818 lb. This compares with 709,978,402 lb. in 1913.

Month.	United States.			Visible Stocks.		
	U. S. Refin'y Production.	Deliveries, Domestic.	Deliveries, for Export.	United States.	Europe.	Total.
Year, 1912....	1,581,920,287	819,665,948	746,396,452	.....	.....	.....
I, 1913.....	143,479,625	65,210,030	60,383,845	105,312,582	78,491,840	183,804,422
II.....	130,948,881	59,676,492	72,168,523	123,198,332	77,504,000	200,702,332
III.....	136,251,849	76,585,471	77,699,306	122,302,890	81,244,800	203,547,690
IV.....	135,353,402	78,158,837	85,894,727	104,269,270	87,180,800	191,450,070
V.....	141,319,416	81,108,321	68,285,978	75,549,108	85,948,800	161,497,908
VI.....	121,860,853	68,362,571	68,067,901	67,474,225	77,235,200	144,709,425
VII.....	138,074,602	58,904,192	78,480,071	52,814,606	71,904,000	124,718,606
VIII.....	131,632,362	73,649,801	73,263,469	53,594,945	66,420,480	120,015,425
IX.....	131,401,229	66,836,897	73,085,275	38,314,037	63,716,800	102,030,837
X.....	139,070,481	68,173,720	68,123,473	29,793,094	53,625,600	83,418,694
XI.....	134,087,708	48,656,858	70,067,803	32,566,382	48,787,200	81,353,582
XII.....	138,990,421	21,938,570	73,542,413	47,929,429	46,592,000	94,521,429
Year, 1913....	1,622,450,829	767,261,760	869,062,784	.....	.....	.....
I, 1914.....	131,770,274	47,956,955	87,955,501	91,438,867	53,916,800	145,355,667
II.....	122,561,007	47,586,657	83,899,183	87,296,685	50,108,800	137,405,485
III.....	145,651,982	69,852,349	89,562,166	78,371,852	47,376,000	125,747,852
IV.....	151,500,531	63,427,633	82,345,216	64,609,319	46,435,200	111,044,519
V.....	142,308,287	55,592,170	72,710,477	70,337,001	52,371,200	122,708,201
VI.....	141,345,571	46,227,353	73,350,196	84,342,641	61,062,400	145,405,041
VII.....	.....	.....	.....	106,110,663	64,220,800	170,331,463
VIII.....	.....	.....	.....	.....	66,499,880	.....
IX.....	.....	.....	.....	.....	*68,277,440	.....
X.....	.....	.....	.....	.....	*66,234,560	.....
XI.....	.....	.....	.....	.....	*73,059,840	.....
XII.....	.....	.....	.....	.....	†49,817,600	.....

* German stock estimated.
† German stock omitted.
Note.—Visible supplies in Europe do not include copper afloat.

In the following table the consumption of refined copper is approximately shown for the past 10 years.

CONSUMPTION OF COPPER IN THE UNITED STATES (*a*)

Year.	Production.	Stock Jan. 1.	Imports.	Supply.	Exports.	Stock Dec. 31.	Consumption.
1905...	875,241,741	208,376,672	210,724,685	1,294,343,098	548,772,403	132,587,496	612,983,199
1906...	917,620,000	132,587,496	225,593,281	1,275,800,777	467,839,041	139,385,400	668,576,336
1907...	1,152,747,890	9,000,000	5,000,000	1,166,747,890	508,929,401	120,000,000	537,818,489
1908...	1,152,895,019	120,000,000	.....	1,272,895,019	661,876,127	122,357,266	488,661,626
1909...	1,405,403,056	122,357,266	.....	1,527,760,322	682,846,726	141,766,111	703,147,485
1910...	1,452,122,120	141,766,111	.....	1,593,888,231	708,316,543	122,030,195	763,541,493
1911...	1,431,938,338	122,030,195	.....	1,553,968,533	786,553,208	89,454,695	677,960,630
1912...	1,581,920,287	89,454,695	.....	1,671,374,982	775,000,658	105,312,582	791,061,742
1913...	1,622,456,829	105,312,582	.....	1,727,769,411	926,441,142	91,348,867	709,979,402
1914(*b*)	1,565,640,501	91,438,867	.....	1,657,147,241	840,080,922	173,640,501	643,425,818

(*a*) The statistics in the above table up to 1906 inclusive are computed in the old way, namely, on the basis of the production of blister copper and the imports of copper in all forms. The stock on hand at the beginning and end of the year includes not only refined copper, but also the crude copper in transit and in process of refining. The statistics since 1906 are computed on the new and more accurate method described in *Eng. Min. Jour.*, July 25, 1908. Briefly, in this method the basis is production of refined copper, stock of copper in final marketable form and imports of refined copper. This change in method explains the erratic appearance of the figures for 1907 as compared with those of 1906. (*b*) U. S. Geol. Surv. estimate.

The sum of Production, Stock Jan. 1, and Imports is the Supply. The Exports are different from deliveries for Export, and are obtained from the statistical report of the Department of Commerce. The Supply less the Exports and the Consumption gives the stock Dec. 31.

Deliveries of refined copper by quarters are shown in the following table for the years 1909 to 1914, inclusive, both for domestic and foreign consumption. The amounts for the different 3-month periods differ

DELIVERIES OF COPPER

Year.		Domestic.	Foreign.
1909	I	144,312,706	128,659,336
	II	169,300,451	206,619,321
	III	187,240,245	173,479,455
	IV	202,736,991	171,074,403
1910	I	207,621,527	159,646,957
	II	180,654,369	142,723,782
	III	188,940,464	196,345,443
	IV	172,210,182	223,715,303
1911	I	158,678,344	157,400,885
	II	178,607,174	195,568,675
	III	174,229,530	195,560,329
	IV	198,096,557	206,372,344
1912	I	186,059,735	202,095,566
	II	208,362,352	184,187,921
	III	213,277,609	190,871,277
	IV	211,966,252	169,241,688
1913	I	201,471,993	210,251,674
	II	227,629,729	222,248,606
	III	199,390,890	224,828,815
	IV	138,769,148	211,733,689
1914	I	165,395,961	261,416,850
	II	165,247,156	228,405,889

considerably, and if a table were prepared showing the variations from month to month the departures would be still more conspicuous. However, when the yearly deliveries are considered there is a steady increase noticeable, especially in the case of foreign takings. It is interesting to note that the domestic consumption has lately been smaller than at any time during the last few years, while the foreign deliveries have continually increased and are at present far in excess. This seems to indicate a more liberal use of copper among foreign countries, especially in Germany.

There is great variation from one quarter to the next in the deliveries, both for home as well as foreign consumption. The use of copper by the manufacturers is probably very steady, but is entirely different from the deliveries made by the refiners, since these are made only when the manufacturer wishes to replenish his stock. This accounts for the erratic character of the data from quarter to quarter, and at the same time explains the steady increase in consumption from year to year as the uses for copper have multiplied. If the figures were complete for the year

1914, the foreign deliveries would show a heavy decrease in the fourth quarter, on account of the chaotic condition of the export trade as a result of the war, while the domestic consumption would probably be nearly uniform.

Exports.—According to the Bureau of Foreign and Domestic Commerce, the exports of copper ore, matte, and regulus from the United States during 1914 was as shown in the following table.

EXPORTS OF COPPER FROM THE UNITED STATES (a)
Ore, matte and regulus stated in tons of 2240 lb. Ingots, etc., in pounds.

Country.	1909.	1910.	1911.	1912.	1913.	1914.
Ore, matte and regulus	59,880	43,784	57,915	66,171	65,684	43,529
Ingots and scrap (b) Exported to:						
United Kingdom....	156,511,113	98,030,213	108,061,603	95,422,292	33,679,641	198,382,459
Belgium.....	6,016,861	7,176,258	5,125,004	7,674,273	7,102,120	5,429,717
France.....	99,003,962	116,193,850	135,038,893	131,362,694	160,000,345	150,839,897
Germany.....	138,213,290	175,861,028	190,428,008	252,156,012	307,150,761	176,698,948
Italy.....	26,386,069	34,110,237	38,216,773	47,251,432	41,568,713	67,415,944
Netherlands.....	204,378,211	221,764,806	230,693,649	152,618,177	178,940,289	126,001,150
Russia.....	3,519,216	6,848,311	15,601,688	4,961,473	7,907,672	8,731,272
Austria Hungary...	.....	.....	44,200,202	38,558,151	34,648,205	26,989,548
Other Europe.....	41,661,979	42,203,861	9,254,363	8,960,973	14,357,014	45,634,229
Brit. North America	6,790,410	5,628,487	8,931,582	30,302,856	36,182,257	24,221,498
Other countries.....	319,328	499,492	1,001,443	5,732,325	4,904,125	9,736,260
Total.....	682,846,726	708,316,543	786,553,208	775,000,658	826,441,142	840,080,922

(a) The exports of ore, matte and regulus are reported as gross weight, the copper contents not being stated. (b) Includes bars and plates.

The figures indicate the greatest shipments of copper to Great Britain during 1914 that have occurred for many years, probably on account of the increased demand for copper created by the war. In contrast with this increase is the decided falling off in the shipments to Germany, also chargeable to the effects of the European war. Early in the conflict England adopted a policy to prevent all shipments of copper from reaching Germany by placing copper on the contraband list, and even went farther than that, detaining several shiploads that were consigned to neutral nations. Through these drastic measures England virtually stopped all copper shipments to the rest of Europe, excepting France, and brought on the conditions that have so materially affected the copper industry of this country. Up to January 1, 1915, 31 shipments of copper to neutral Continental ports were seized by Great Britain. These seizures aggregated 19,350 tons, of which 9350 tons was piled up at Gibraltar alone. Four of the shipments were destined for Holland, 14 for Italy, and 13 for Sweden.[1] In spite of representations made by our government, England refused to permit copper shipments to proceed to neutral ports, and American owners of the copper agreed to sell their products

[1] New York *World*, Feb., 1915.

to the British government at a reduced rate, rather than institute prize-court proceedings, which are always protracted and expensive.

Imports.—According to the report of the Bureau of Foreign and Domestic Commerce, the copper imported in the form of ore, matte, and regulus during 1914 was 104,801,324 lb. net; and in the form of pigs, bars, ingots, plates, and scrap was 201,549,503 lb. These figures are less in both instances than those of 1912 and 1913, as seen in the accompanying table. The total value of the imported copper in 1914 is estimated by the Bureau of Commerce as $39,986,004.

World's Production

Statistics on the world's production of copper as given in the accompanying table are taken mainly from the figures of the *Engineering and Mining Journal* and from those compiled by Henry R. Merton & Co. In all cases the production from domestic raw products and ore only are included, and for the reason that in a few cases some of them may have been exported without recording them, the figures may be low.

IMPORTS OF COPPER INTO THE UNITED STATES (a)
(In pounds)

Country.	1909.	1910.	1911.	1912.	1913.	1914.
Ore and matte Imported from:						
Germany	.....	.....	.....	.....	1,067,024	4,634,448
Spain	.....	.....	.....	.....	6,244,676	2,832,205
Cuba	.....	.....	.....	.....	5,362,132	18,669,753
Brit. North America	9,689,829	10,024,806	12,919,644	28,930,073	34,072,096	24,204,104
Mexico	23,914,040	22,731,184	16,684,071	18,069,987	19,722,530	15,495,824
South America	20,987,197	19,425,233	15,305,335	26,749,545	(c) 25,311,542	(c) 30,563,230
Other countries	26,496,327	33,033,752	23,717,628	31,122,098	17,712,105	8,460,220
Total	81,087,393	85,224,975	68,626,678	104,871,703	109,492,105	104,801,324
Pig and Scrap (b) Imported from:						
United Kingdom	26,527,574	18,649,727	9,004,461	1,404,118	17,943,285	5,163,126
Other Europe	27,379,175	25,411,383	28,042,257	31,670,095	(d) 36,565,767	(d) 16,921,731
Brit. North America	29,196,351	29,016,785	22,442,335	36,138,255	33,749,133	27,220,557
Mexico	76,119,724	84,008,907	97,115,574	124,742,193	97,003,847	43,193,887
Chile	.....	.....	5,175,823	8,627,421	18,315,000	23,814,000
Peru	.....	.....	42,545,031	43,891,439	42,667,436	10,918,000
Australia and Tasmania	.....	.....	22,426,670	24,700,333	22,149,335	44,488,200
Japan	23,830,140	18,482,989	20,030,447	19,511,402	14,367,493	15,120,021
Other countries	55,797,329	83,640,995	19,197,254	14,684,336	17,298,533	14,672,000
Total	238,850,293	259,210,786	265,980,760	305,369,592	300,059,829	201,549,503

(a) The imports reported are the copper contents of ore, matte, and regulus. (b) Includes also bars, ingots, and plates. (c) All from Chile. (d) All from Spain.

The effect of the European war on the copper industry of the world can plainly be seen by comparing the production figures of the past year with those of the preceding 2 years. Prospects at the beginning of the year were that all previous records would be broken, and the progress the first 7 months shows that in all probability that would have been

the case had no interruption occurred. The policy of curtailment adopted by the larger producers, following the outbreak of the war and the consequent slump in the market, caused the output of the last few months to run far below the normal, but the heavy demand for copper for war purposes soon restored the market and the industry gradually got back to average production by the close of the year. However, the excess production of the first 7 months was not sufficient to counterbalance the loss due to curtailment, so that a net loss of 78,496 tons was sustained.

THE WORLD'S COPPER PRODUCTION
(In metric tons)

Country.	1905.	1906.	1907.	1908.	1909.	1910.(h)	1911.	1912.	1913.	1914.
Africa (a) Cape Co...	5,105	4,003	4,298	4,550	4,720	7,016	17,252	16,633	5,812	3,125
Africa (a) Namaqua	2,337	2,642	2,540	2,440	2,337				2,540	2,328
Africa (a) Other	.....	.....	.....	.....	8,128	8,433	.....	.....	17,059	18,682
Argentina (a).....	157	107	224	226	610	305	1,036	335	117	.....
Australasia (a).....	34,483	36,830	41,910	40,123	34,952	40,962	42,512	47,774	47,326	37,592
Austria-Hungary (a)	1,346	1,458	1,062	3,877	6,218	2,276	2,566	4,024	4,135	3,310
Bolivia (a).....	2,032	2,540	21,035	2,540	2,032	2,540	(d) 2,950	(d) 4,681	3,658	2,743
Canada (d).....	21,595	19,110	2,540	24,376	21,626	23,810	25,570	34,213	34,587	34,027
Chile (d).....	29,126	25,829	28,863	42,097	42,726	38,346	33,088	39,204	40,195	40,876
Cuba (d).....	.....	1,384	1,388	2,966	3,006	3,538	3,753	4,393	3,517	6,251
Germany—total (a).	22,492	20,665	20,818	20,523	32,815	25,105	22,363	24,304	25,309	30,480
(Mansfeld) (a) ,,	(19,878)	(18,085)	(17,343)	(18,000)	(19,015)	(20,275)	.....	.....	(20,201)	.....
Italy (a).....	2,997	2,911	3,353	3,022	2,769	3,272	2,642	2,337	1,626	2,410
Japan (f).....	35,944	36,963	40,183	41,399	42,987	50,703	d) 52,303	d) 62,486	a) 73,152	68,058
Mexico—total (d)...	65,449	61,615	57,491	38,190	57,230	62,504	61,884	73,617	52,815	36,337
(Boleo) (a).....	(10,341)	(11,002)	(11,506)	(12,600)	(12,426)	(13,003)	.....	.....	(13,020)	.....
Newfoundland (a)..	2,316	2,332	1,758	1,453	1,402	1,097	1,174	549	.....	.....
Norway (a).....	6,406	6,218	7,122	9,337	9,226	10,592	9,576	11,156	11,796	.....
Peru (e).....	12,213	13,474	20,681	15,240	16,257	27,375	28,500	f) 26,483	d) 25,715	23,647
Russia (c).....	9,515	9,296	15,930	17,718	18,035	22,670	25,747	33,550	42,970	31,938
Spain-Portugal (a)..	45,527	50,109	50,470	53,425	53,023	51,080	51,748	59,876	54,696	37,099
Rio Tinto (a)....	32,795	34,642	32,833	35,517	35,938	(34,114)	(35,100)	.....	36,901	21,515
Tharsis (a).....	4,415	4,816	4,206	4,500	4,425	(3,551)	(3,450)	.....	3,270	.....
Mason & Barry (a)	2,764	2,504	2,662	2,804	2,403	(3,003)	(2,972)	.....	3,185	.....
Sevilla (a).....	1,300	2,073	2,337	2,196	1,849	(1,656)	(1,558)	.....	1,535	.....
Sweden (c).....	1,385	1,200	1,577	2,808	2,032	2,032	2,032	(a) 1,524	(a) 1,016	.....
Turkey (a).....	711	432	1,270	1,068	813	610	1,016	508	508	.....
United Kingdom (g)	727	762	677	588	442	508	405	405	305	.....
United States (d)...	397,069	416,343	398,930	430,399	501,372	492,720	491,634	563,260	557,387	525,529
Total.....	698,931	715,510	724,120	758,065	854,758	877,494	879,751	1,011,312	1,002,284	923,888

(a) As reported by Henry R. Merton & Co., Ltd., of London. (c) As officially reported, except for 1909, for which year the figure of Henry R. Merton & Co. is used. (d) As reported by the *Eng. Min. Jour.* (e) As officially reported 1903–1907, as per Henry R. Merton & Co. for 1908 and 1909. (f) As officially reported. (g) As officially reported, 1900–1905; subsequently as per Henry R. Merton & Co. (h) Henry R. Merton & Co., through *Eng. Min. Jour.*

WORLD'S PRODUCTION OF COPPER (a)

Year.	Metric Tons.	Short Tons.	Year.	Metric Tons.	Short Tons.	Year.	Metric Tons.	Short Tons.
1882....	184,620	203,550	1893...	310,704	342,562	1904...	693,240	764,758
1883....	202,697	223,481	1894...	330,075	363,920	1905...	698,931	770,221
1884....	223,884	246,840	1895...	339,994	374,856	1906...	715,510	788,492
1885....	229,315	252,828	1896...	384,493	423,917	1907...	724,120	798,205
1886....	220,669	243,295	1897...	412,818	455,147	1908...	758,065	835,623
1887....	226,492	249,716	1898...	441,282	486,529	1909...	854,758	942,408
1888....	262,285	281,179	1899...	476,194	525,021	1910...	877,494	966,998
1889....	265,516	292,741	1900...	491,435	541,561	1911...	879,751	969,750
1890....	274,065	302,166	1901...	529,508	583,517	1912...	1,011,312	1,114,769
1891....	280,138	308,862	1902...	542,606	597,951	1913...	1,002,284	1,104,517
1892....	309,113	340,808	1903...	630,590	694,910	1914...	923,888	1,018,395

(a) The statistics for 1881–1891 are as reported by Henry R. Merton & Co.; 1892–1910 as per MINERAL INDUSTRY.

Price.—The price of copper declined steadily during 1914 from its highest point at the beginning of the year, when electrolytic commanded close to 15 cts., to the lowest price of the year in November, when the price had reached its lowest ebb at 11.10 cts. During the rest of the year the price improved gradually, rising to 13.2 cts. in December, but

AVERAGE PRICE OF ELECTROLYTIC COPPER PER POUND IN NEW YORK (a)

Year	Jan.	Feb.	Mar.	April.	May.	June.	July.	Aug.	Sept.	Oct.	Nov.	Dec.	Year.
	Cts.	Cts.	Cts.	Cts.	Cts.	Cts.	Cts.	Cts.	Cts.	Cts.	Cts.	Cts.	Cts.
1904.	12.410	12.063	12.299	12.923	12.758	12.269	12.380	12.343	12.495	12.993	14.284	14.661	12.823
1905.	15.008	15.008	15.125	14.920	14.627	14.673	14.888	15.664	15.965	16.279	16.599	18.328	15.590
1906.	18.310	17.869	18.361	18.375	18.457	18.442	18.190	18.380	19.033	21.203	21.833	22.885	19.278
1907.	24.404	24.869	25.065	24.224	24.048	22.665	21.130	18.356	15.565	13.169	13.391	13.163	20.004
1908.	13.726	12.905	12.704	12.743	12.598	12.675	12.702	13.462	13.388	13.354	14.130	14.111	13.206
1909.	13.893	12.949	12.387	12.563	12.893	13.214	12.880	13.007	12.870	12.700	13.125	13.298	12.982
1910.	13.620	13.332	13.255	12.733	12.550	12.404	12.215	12.490	12.379	12.553	12.742	12.581	12.738
1911.	12.295	12.256	12.139	12.019	11.989	12.385	12.463	13.405	12.201	12.189	12.616	13.552	12.376
1912.	14.094	14.084	14.698	15.741	16.031	17.234	17.190	17.498	17.508	17.314	17.326	17.376	16.341
1913.	16.488	14.971	14.713	15.291	15.436	14.672	14.192	15.400	16.328	16.337	15.182	14.224	15.269
1914.	14.223	14.491	14.131	14.211	13.996	13.603	13.223	(b)	(b)	(b)	11.739	12.801	.....

(a) From *Eng. Min. Jour.* (b) No quotation.

AVERAGE PRICE OF STANDARD COPPER (G. M. B.'s) IN LONDON (a)
(In pounds sterling per ton of 2240 lb.)

Year.	Jan.	Feb.	Mar.	April.	May.	June.	July.	Aug.	Sept.	Oct.	Nov.	Dec.	Year.
1903.....	53.52	57.34	63.85	61.72	61.73	57.30	56.64	58.44	56.82	55.60	56.30	56.36	57.97
1904.....	57.500	56.500	57.321	58.247	57.321	56.398	57.256	59.952	57.645	60.012	65.085	66.375	58.884
1905.....	68.262	67.963	68.174	67.017	64.875	65.881	66.887	69.830	69.667	71.406	74.727	78.993	69.465
1906.....	78.869	78.147	81.111	84.793	84.867	83.994	81.167	83.864	87.831	97.269	100.270	105.226	87.282
1907.....	106.739	107.356	106.594	98.625	102.375	97.272	95.016	79.679	68.375	60.717	61.226	60.113	87.007
1908.....	62.386	58.786	58.761	58.331	57.387	57.842	57.989	60.500	60.338	60.139	63.417	62.943	59.902
1909.....	61.198	57.688	56.231	57.363	59.338	59.627	58.556	59.393	59.021	57.551	58.917	59.906	58.732
1910.....	60.923	59.388	59.214	57.238	56.313	55.310	54.194	55.733	55.207	56.722	57.634	56.069	57.054
1911.....	55.604	54.970	54.704	54.035	54.313	56.368	56.670	56.264	55.253	55.176	57.253	62.063	55.973
1912.....	62.760	62.893	65.884	70.294	72.352	78.259	76.636	78.670	78.762	76.389	76.890	75.516	72.942
1913.....	71.741	65.519	65.329	68.111	68.807	67.140	64.166	69.200	73.125	73.383	68.275	65.223	68.355
1914.....	64.304	65.259	64.276	64.747	63.182	61.336	60.540	(b)	(b)	(b)	53.227	56.841	.....

(a) From *Eng. Min. Jour.* (b) No quotation.

AVERAGE MONTHLY PRICES OF COPPER MANUFACTURES (a)
(In cents per pound)

	1913.		1914.	
	Wire.	Sheet.	Wire.	Sheet.
Jan.	19.09	23.50	15.94	20.75
Feb.	16.38	22.50	15.88	20.50
Mar.	16.39	21.50	15.60	20.35
Apr.	16.50	21.50	15.25	20.25
May	16.50	21.50	15.23	19.90
June	16.18	21.10	15.03	19.56
July	15.88	20.50	14.88	19.38
Aug.	16.60	21.50	14.63	18.80
Sept.	17.84	22.50	14.34	18.00
Oct.	17.75	22.50	13.34	17.38
Nov.	17.28	21.15	12.50	17.50
Dec.	15.79	20.50	14.25	18.88
Year	16.85	21.69	14.74	19.24

(a) *Eng. Min. Jour.*

declined again to 12.70 before the close of the year. The average price for the year was about 13.5, as compared with 15.5 for the year 1913. The highest monthly average was recorded in February, at 14.49, and the lowest monthly average occurred in November, at 11.74 cts. During the first half of the year the price held up to an average of 14.11 cts. in spite of the heavy rate of production, but after the outbreak of the war the market soon became overstocked and the price dropped rapidly to the lowest mark recorded for more than 10 years.

Copper Mining in the United States

Alaska.—The production of copper in Alaska during 1914 shows a slight increase over that of the previous year in spite of the discouraging conditions of the copper market during the latter part of the year. The smelter production figures show that 24,985,847 lb. of copper was recovered during the year, as compared with 23,423,070 lb. in 1913.[1] The developments made up to midsummer gave promise that 1914 would be the most profitable year in the history of Alaska copper mining, but the financial stringency and the collapse of the copper market that followed the breaking out of the European war not only closed down some of the producing mines, but also put a stop to some very important developments. Up to about the first of August seven copper mines were in steady operation, but at the close of the year only three were still working. Had it not been for the war, at least nine copper mines would have been ready to ship ore before the end of the year. Probably the most important events of the year to the copper industry were the re-opening of the Mamie mine, in the Ketchikan district; the installation of a shipping plant, and the opening of the Midas mine, near Valdez; and the completion of aerial trams at the Jumbo and Mother Lode mines, in the Chitina district.[2]

The Kennecott Mines Co. curtailed its production to such a point that at the end of the year it was not operating its concentrator, but merely shipping high-grade ore from the Bonanza and Jumbo mines, which were each working at about half capacity. The Jumbo, which began producing regularly in December, proved to be equal to the Bonanza itself, or to surpass it both in richness and in quantity.

Among the other companies the Mother Lode continued active operations and made some valuable discoveries during the year. The Hubbard-Elliot continued its work, and the same is true of the Alaska Consolidated, the Great Northern, and the Rarus group.

In and around Prince William Sound two copper mines were operated.

[1] Advance statement, U. S. Geol. Surv.
[2] Mining in Alaska in 1914, A. H. Brooks, *Salt Lake Min. Rev.*, Jan. 30, 1915.

The Beatson Copper Co., on Latouche Island, almost completed its new concentrator from which production was expected to begin early in 1915. This mill embraces both gravity and flotation methods. New concentrate bins and docks provided with a conveyor belt for loading were erected. The mill is connected with the mine by means of a 2000-ft. tunnel, but mining is done in an open cut. About 50,000 tons was mined and shipped during the year.

The Ellamar Co. during the year completed an aerial tramway connecting its shaft bins with deep water loading facilities and having a capacity of 200 tons per hour. The discharge station is 2200 ft. out in the bay from the loading station, and the system required the erection of six towers. The year's production of the mine is about 30,000 tons, which might have been greatly increased if market conditions had justified.

The Three-Man Mining Co., on Landlock Bay, developed through the year and has several hundred tons of copper ore ready for shipment. No attempts were made to take out ore except as development work required. The property is under option.

Arizona.—During 1914 Arizona maintained its previously acquired rank as the greatest copper-producing state of the Union. The output for the year was somewhat less than that of 1913, but considering the serious interference of the war in the American copper industry during the last half of the year, the production was surprisingly large. The average rate of production was well above 1,000,000 lb. per day for the year, the final total being 387,978,852 lb., as compared with 399,489,745 lb. in 1913. These figures indicate a decrease of a little less than 1,000,000 lb. per month for 1914, and it is safe to say that, had not the war forced upon the principal copper producers a policy of curtailment of production, the output would have been far in advance of that of 1913. Figures for the first seven months of 1914 indicate that during that part of the year the production ran about 30,000,000 lb. ahead of the output for the corresponding months of 1913,[1] and it seems fair to assume that, had nothing intervened, the total for 1914 would have been nearly double that amount, so that the curtailment in Arizona's production probably amounted to nearly 75,000,000 lb.

The Calumet & Arizona Mining Co.'s (Warren, Ariz.) report for 1914 shows a net income of $3,058,536 from all sources, including subsidiary companies. Total receipts were $8,518,998, of which $14,984 came from miscellaneous sources and the remainder from metals produced. Expenditures were $5,303,375 for operations and $130,089 for outside properties. Dividends aggregated $1,851,008. The net cost of refined copper after deducting the value of precious metals was 8.19 cts. per lb.

[1] Copper in Arizona, by James Douglas, *Eng. Min. Jour.*, Jan. 9, 1915.

The value of precious metals was $28.35 per ton of refined copper. The production of refined copper, gold and silver follows:

	Produced from		
	Domestic Ore.	Purchased Ore.	Total.
Pounds copper	49,992,909	2,675,020	52,667,929
Ounces silver	573,606	348,537	922,143
Ounces gold	19,745	4,377	24,122

The Calumet & Arizona mine produced 66,467 dry tons of ore and performed 6328 ft. of development work, which is about 1 ft. for 10.7 tons of ore mined, as compared with 6.8 tons in 1913. The Superior & Pittsburgh mine produced 505,001 tons of ore and performed 66,465 ft. of developmental work, or about 1 ft. for 8 tons of ore.

The smeltery treated 668,776 dry tons of ore, of which 138,725 tons was custom ores. The blast furnaces handled 403,269 tons of ore and 31,299 tons of slag and cleanings. The reverberatory department handled 238,095 tons of charge and the roasting department, with an average of seven furnaces operating, roasted 209,138 wet tons of ore. The average sulphur contents of the ore treated were 27.5 per cent. and the calcines produced contained 9 per cent. sulphur. The converters produced 32,058 tons of blister copper. Siliceous material to the amount of 24,823 tons was treated in the converters.

The one new large-scale project of the year in Arizona is the development of the property of the New Cornelia Copper Co. in the Ajo district.[1] It is controlled by the interests prominent in the Calumet & Arizona Co., and its mining and metallurgy is to be conducted by the staff of that company. The ores are of low grade, part sulphide and part oxidized, and an attempt is being made to extract them by mixing in certain ores of the Calumet & Arizona mines whose ingredients can be applied to the extraction of the Ajo ores.[2]

To develop the New Cornelia property, the ground considered as probably ore-bearing was coördinated with east-west and north-south lines at 200-ft. intervals and drill holes were sunk at the intersections.

After 6 months of drilling, test-pitting was begun for the sake of checking the drilling results. The pits were about 4 by 6 ft. in size, sunk with windlass and hand drills, Mexican and Papago Indian miners being employed. The work was done on contract, and after practice, the men became so efficient that up to a depth of 50 ft., test-pitting was cheaper than diamond drilling. During the last year of development, test pits were sunk 50 ft. deep on the coördinate points in advance of the drilling, in order both to expedite the work and to decrease the drilling cost.

Every tenth bucket hoisted from each hole was taken for a sample and large samples were thus obtained for every round shot. Then after the pit was completed, it was re-sampled in 5-ft. sections by cutting a

[1] For an extended account of the Ajo district, see *Eng. Min. Jour.*, Oct. 10, 1914.
[2] J. Douglas, *Eng. Min. Jour.*, Oct. 10, 1914.

rectangular vertical groove 3 in. deep by 6 in. wide, so as to give about a 500-lb. sample for each 5-ft. section. These channel samples averaged about 0.15 per cent. lower than the bucket samples, and were taken for the final samples of the pit.

In the sulphide ore the pits encountered water, which made sinking so slow that only a few hundred feet was done in the sulphide zone. However, to check more thoroughly the drilling results in the sulphide and prove a constant grade of ore between drill holes, drifts were run on coördinate lines from the bottoms of two of the deepest test pits and raises were put up from these drifts to check the drill holes. For the sake of giving accurate samples the material broken in each round was hoisted separately, dumped on an iron plate, and every tenth shovelful taken out for the large sample to be cut down later.

Up to September, 1913, when development work was stopped, 84 diamond-drill holes had been bored, varying in depth from 200 to 1000 ft. and giving a total footage of 23,097. Of these, 19 were stopped in ore. In all, 77 test pits were sunk with a total footage of 3955; of this, 3606 ft. was in carbonate ore and 349 in sulphide; 1059 ft. of the test pitting checked drill holes in carbonate ore, 175 ft. checked drill holes in sulphide, and 2721 was done in advance of drilling. The drifting in the sulphide ore amounted to 1513 ft. and the combined sinking and raising on drill holes in sulphide ore was 317 ft.

The sinking, drifting and raising checked the drilling accurately. The channel samples of the test pits in carbonate averaged 0.005 per cent. lower than the corresponding diamond-drill samples; the test pits and raises in sulphide averaged 0.05 per cent. lower than the diamond-drill samples; and the drifts in sulphide averaged 0.26 per cent. higher than the assay value of the blocks through which they were run, as indicated by the drill holes at the corners of the blocks. In calculating the ore, drill samples were used wherever drilling was done, and channel samples of test pits were used where sinking was done in advance of drilling. The estimate of the ore developed is as follows:

	Tons.	Copper, Per Cent.
Ore estimate:		
Carbonate	11,954,400	1.54
Sulphide	28,303,600	1.50
Total	40,258,000	1.51
Available by steam shovel:		
Carbonate	11,954,400	1.54
Sulphide	20,526,800	1.54
Total	32,481,200	1.54
Not available by steam shovel:		
Sulphide	7,776,800	1.40
Rock which must be removed to make steam-shovel tonnage available:		
Rock in carbonate zone	708,400	0.65
Rock in sulphide zone	2,600,000	0.63
Total rock	3,308,400	0.63

The gold and silver content is low, generally amounting to less than 15 cts. per ton. In computing the tonnage, no material running under 1 per cent. in copper was included. The estimate of ore available for steam shoveling depends on the assumed maximum grade of track in approaches and pits, and on amount of lean rock in the sides and bottom of the pit which it will pay to remove in order to get access to the ore. It is likely that the proportion removed by steam shovel will be greater than that indicated in the table. Not only will there be no stripping expense, but the absence of overburden precludes the possibility of lowering grades by the admixture of barren material. Both tonnage and content of copper, therefore, should come out closely to the estimate.

The ore-body already developed will supply a 4000-ton mill for over 26 years, or a 6000-ton mill for over 18 years. Indications are that the life of the mine will be greatly lengthened by the development of a large tonnage of deep ore along the fracture zone in the center of the ore-body. For the next quarter of a century, the Ajo will be one of the greatest copper districts of the southwest.

The report for 1914 of the Ray Consolidated Copper Co., Ray, Ariz., shows a production of 57,004,281 lb. of refined copper, 51,608 oz. of silver, and 306,532 oz. of gold. Dividends were paid in March and June aggregating $1,089,322, making total dividends to date of $2,720,826. The mill treated 2,427,700 tons of ore averaging 35.2 lb. of copper per ton, and 2591 tons of ore averaging 237.34 lb. per ton was shipped to smelters. The average net yield in refined copper per ton of ore treated was about 23.5 lb. The accompanying table gives a summary of the total production:

TOTAL PRODUCTION OF RAY CONSOLIDATED

Year.	Tons of Ore.	Lb. Cu per Ton.	Total Lb. Refined Copper Prod.	Value of Other Metals.
1911	618,519	21.9	14,935,047	$926
1912	1,565,875	22.2	34,674,275	8,269
1913	2,365,296	22.2	52,341,029	51,396
1914	2,430,291	23.5	57,004,281	34,761
Total	7,042,981	22.6	158,954,632	$95,352

During the first 7 months of 1914 the plants were running at about full capacity, but with the beginning of the war, production was cut to 50 per cent. of normal capacity.

The total development during the year was 75,261 ft., which is 9468 ft. less than in 1913. Development since the commencement of mining operations to the end of 1914 amounts to 452,233 ft., or about 85 miles. Of this, about 34 miles has been destroyed by mining operations. It is

stated that the mine is now thoroughly opened, so that all production requirements may be easily met.

The ore reserves have been re-calculated and were estimated on Dec. 31, 1914, to contain 74,765,789 tons averaging 2.214 per cent. copper. This ore underlies an area of 205.2 acres. This re-calculated tonnage is about 1.5 per cent. less than the former estimate; but to offset this, the copper contents indicated by the new data obtained raise the average grade about 1 per cent. This new estimate was made after exploring the margin of the main ore-body.

During the second quarter of the year the average daily output was 8296 tons. A total of 2,429,330 tons was mined, of which 2591 tons was shipped to the smelter; the remainder was concentrating ore and averaged 1.7604 per cent. copper.

It is estimated that there is a reserve of 5,000,000 tons of broken ore in the stopes. Mining cost was 62.42 cts. per ton, compared with 73.23 cts. in 1913. This cost includes general fixed charges and the cost of coarse crushing and loading the ore into cars. The cost of crushing and loading into cars was 3.1 cts. per ton, making the mining cost proper 59.32 cts. per ton. Eliminating No. 3 shaft, where the cost of mining is higher on account of square setting, the cost was 54.21 cts. per ton.

If the milling plant had operated during the last of the year at the same rate as during the first half, the year's tonnage would have been 3,006,129 tons. Mill ore averaged 1.76 per cent. copper, and the average rate of extraction was 67.88 per cent. The cost of milling was 49.88 cts. per ton, compared with 51.93 cts. for 1913. The average grade of concentrates was 19.25 per cent., compared with 18.55 in 1913.

The average cost per lb. of refined copper was 8.868 cts., after crediting earnings from the railroad. The combined cost of refined copper from milling and shipping ore was 8.839 cts. per lb. These costs include all operating and general charges. By crediting all miscellaneous income to cost, the net cost of copper produced was 8.763 cts. per lb.

No new construction work is contemplated during the coming year, but some changes in the milling practice are being considered which will require incidental changes in the mechanical arrangements.

Phelps, Dodge & Co., with an authorized capital of $50,000,000, $45,000,000 issued, controls the following operating companies: Copper Queen Consolidated Mining Co., Detroit Copper Mining Co. of Arizona, Moctezuma Copper Co., Burro Mountain Copper Co., Stag Cañon Fuel Co., and the Phelps-Dodge Mercantile Co.

The total copper ore extracted from the mines amounted to 1,777,243 tons, of which 1,046,728 tons was submitted to preliminary concentration and 730,515 tons smelted direct. The quantity of copper made during

the year 1914 by the constituent companies controlled by Phelps, Dodge & Co. was 140,231,384 lb., of which 8,569,060 lb. was made from the Miami Co.'s ores and the resulting product in blister copper was delivered to them. Including copper received from outside sources, 188,687,378 lb. was sold and delivered to buyers at an average price of 13.57 cts. per lb., net cash f.o.b. New York.

The president, James Douglas, states that the current of the copper trade has been deflected from its normal channels, like other markets of the world, by the war which started on August 1. From January to August the demand for copper was more sluggish than it had been in 1913. During the period from August to December both the domestic and foreign demand fell off to such a degree that it became imperative to reduce production. The output of the Douglas and Detroit smelters was contracted 40.48 per cent. As a result, copper shipments from the smelting works of the company during this period were only 59.34 per cent. of normal. The revolutionary movements in Mexico have slightly embarrassed operations there and correspondingly reduced the output.

At both the Copper Queen mine and at the mines of the Moctezuma Copper Co. the visible reserves have been notably increased, and improved methods in both mining and smelting have reduced the cost of production. The tendency of legislation in the new state of Arizona has been somewhat radical, but the people as well as their representatives recognize the dependence of the state on the prosperity of mining and may be counted upon to encourage rather than depress that industry, even though some drastic experiments may be tried before an equitable system of state regulation and taxation will be reached.

The company's revenue from subsidiaries was $6,350,000, and commissions, etc., $541,651, a total of $6,891,651, of which $6,300,000 was paid in dividends. The surplus is $7,011,109. During the year the Tombstone Consolidated property was acquired, and will be operated under the name of the Bunker Hill Mines Co.

The Limestone mine reserves have increased from 211,199 to 257,077 tons of lean sulphide, and 2,357,729 to 2,834,862 tons of mine run ore. Most of the porphyry ores of Sacramento Hill must be submitted to preliminary concentration. Methods of mining in 1914 showed the following: square set, 76.1 per cent.; top slice, 13.9 per cent.; cut and fill, 8.2 per cent.; and shrinkage, 1.8 per cent., in 694,942 tons extracted. Stoping costs were reduced.

The smelter treated 654,669 tons of Copper Queen ore and other material, averaging 6.25 per cent. copper, 0.02 oz. gold, and 1.01 oz. silver, yielding 76,842,973 lb. copper, 14,987 oz. gold, and 627,612 oz. silver. The total material treated in the plant amounted to 1,012,177

tons, yielding 119,957,017 lb. copper, 1,405,301 oz. silver, and 26,259 oz. gold. This included concentrate from the Moctezuma in Sonora, and custom ore. There were 946 men employed in the departments.

Ore shipped to El Paso amounted to 23,930 tons, containing 8,889,175 lb. lead, 399,106 lb. copper, 332,106 oz. silver, and 1822 oz. gold. The experimental plant also treated 3150 tons for 130,342 lb. copper.

The Copper Queen metal output was 86,066,143 lb. copper, 8,889,175 lb. lead, 1,036,672 oz. silver, and 15,769 oz. gold, from 732,829 tons of ore, precipitate, and slag. Net earnings totaled $6,042,001, and $4,500,000 was paid in dividends.

Detroit Copper Mining Co. of Arizona.—The reports of the general manager, A. T. Thomson; mine superintendent, M. H. McLean; and smelter superintendent, V. P. Hastings, contain the following data:

Development amounted to 12,766 ft. in the five principal mines and 13,609 ft. in outside properties, a total of 26,375 ft. Ore production was 217,876 tons from the Ryerson mine, 85,119 from the Yankie, 128,641 from the Copper Mountain, 39,310 from the Arizona Central, 1202 from the Colorado, and 46 from the Antietam, a total of 472,194 tons. This averaged 2.899 per cent. Out of this tonnage, 459,473 tons was concentrating ore. Lessees mined 773 tons containing from 4.71 to 21.19 per cent. copper from 13 mines, and 61.7 tons of precipitate averaged 52.13 per cent. Exploration on the outside property was not encouraging and ore reserves decreased, in spite of good results in the Ryerson and Yankie.

The blast furnace smelted a total of 129,530 tons of mixed charge, and the output of copper was 20,274,367 lb. Net earnings for the year were $602,319, and $280,000 was paid in dividends. There were 1438 men employed.

Moctezuma Copper Co.—This company, in charge of J. S. Williams, Jr., operates at Nacozari, Sonora, Mexico, and has been the scene of revolutionary movements for some time past, and the general manager states that nothing but the political unrest in the country would prevent the property being a more active producer than it has been. (See section on *Mexico*.)

Operations of the United Verde Copper Co. in 1914, compared with the 3 years previous, were as follows:[1]

	1911.	1912.	1913.	1914.
Copper	$4,174,478	$5,279,442	$5,357,840	$4,397,905
Silver	246,685	298,155	381,350	350,447
Gold	315,691	321,860	431,926	438,557
Total	$4,736,834	$5,899,860	$6,171,116	$5,186,909

[1] *Min. Eng. World*, Feb. 27, 1915.

Production of metals compares as follows:

	Copper, Lb.	Silver, Oz.	Gold, Oz.
1908	36,183,089	494,574	20,334
1909	36,694,063	495,480	17,022
1910	38,663,880	563,133	19,267
1911	33,167,987	461,145	15,239
1912	31,565,987	484,222	15,082
1913	35,333,924	641,626	20,664
1914	32,449,116	646,285	21,393

Average prices received for copper, gold, and silver have been as follows:

	Copper, Cents Lb.	Silver, Cents Oz.	Gold, per Oz.
1911	12.586	53.49	$20.72
1912	16.725	61.57	21.34
1913	15.164	59.434	20.902
1914	13.553	54.225	20.50

The new smelter has not yet been completed, but construction could be rushed so that production could start within 60 days. Two furnaces of the old smelter are turning out present production, but the old plant will be abandoned when the new smelter blows in. The new plant will have a normal capacity of 5,000,000 lb. per month.

The Miami Copper Co., Miami, Ariz., for 1914 reports that 1,099,208 tons of ore was hoisted and 1,096,633 tons milled, averaging 2.28 per cent. copper. From this ore 44,579 tons of concentrates was produced, averaging 39.31 per cent. copper. The total copper in concentrates amounted to 35,048,445 lb., of which 33,296,010 lb. was recovered as refined copper. Copper sales for 1914 aggregated 32,879,447 lb. at 14.3488 cts. per lb.

Underground development consisted of 22,865 ft. within the Captain ore-body. On account of the thickness of the ore it is planned to extract it in two lifts, the upper one consisting of ore above the 270-ft. level, from which point a transfer will be made to the main tramming level through specially prepared raises. Blasting of the pillars between the shrinkage stope rooms in the Northwest ore-body was completed in the early part of the year, and the drawing of broken ore started. About 60 per cent. of the total ore hoisted came from this area.

The mill was operated at full capacity during the first 7 months of the year, but production was reduced in the latter part of the year on account of the war. Improvements made proved a success, and plans were made for remodeling the entire plant to treat 4200 tons a day. The change consists principally in finer grinding and additional table treatment on the sand floor of the mill and improved methods of handling and treating the slime products. The increased capacity on the sand floor will be obtained by using double-deck tables, and finer grinding will be accomplished by 8-ft. by 66-in. Hardinge conical pebble mills in the sand-floor tunnels. The product of these mills will be raised by elevators and re-clas-

sified for table treatment. The material leaving the sand floor will have the fine sands removed in 8-ft. conical tanks, the overflow of which will pass to six Dorr thickeners 46 ft. in diam. by 10 ft. deep, one to each section, and located outside of the mill building. The thickened pulp will join the reject from the slime tables for further treatment. The mill bins will be raised to 10,000 tons capacity.

Further prospecting was stopped at the time of the curtailment in production, so no increase in ore reserves is shown except what was opened by current development. Ore reserves are estimated to contain 19,500,000 tons of sulphide ore averaging 2.4 per cent.; 17,000,000 tons averaging 1.21 per cent. copper, and 6,000,000 tons of mixed sulphide and oxidized ore averaging about 2 per cent. copper. Experiments are under way to determine some way to treat this mixed ore, and it is hoped that within a reasonable time this ore will be available for treatment. According to these figures, there are about 13 years of operations on the high-grade ore alone and about 25 years of life on an average grade of 1.85 per cent. ore, if the 17,000,000 tons of 1.21 per cent. ore is considered.

The United Globe Mines, Globe, Ariz., reports a production during 1914 of 11,086,674 lb. of refined copper, 91,582 oz. of silver, and 1579 oz. of gold from 155,205 tons of ore. The average grade of all ore was 3.57 per cent. copper. The receipts from the sale of this ore amounted to $1,095,560. Expenses were $663,022, leaving a net profit of $432,538 for the year. This profit is before deducting depreciation. Dividends totaling $425,500 were paid, making dividends to date $1,955,000. The principal product of the United Globe is concentrating ore.

The Shattuck-Arizona Copper Co., operating mines in Cochise County, smelted 84,801 dry tons of copper ore during 1914. The copper recovery amounted to 10,846,918 lb., and was produced at a net cost of 8.72 cts. per lb. In addition to the copper there was produced 14,065 lb. lead, 198,419 oz. silver, and 2445 oz. gold. The total revenue to the company was $1,660,573, of which $587,497 was net profit. The company paid dividends to the extent of $525,000, leaving on hand cash and metal to the value of $1,045,315. During August, September, and October the output was curtailed to 50 per cent. of the normal, and finally the mine was closed, as a result of the depression in the copper industry. Development work is reported to show encouraging results on the 200-, 400-, 700-, and 850-ft. levels in the copper area, and the mine is said to be in good condition.

The Old Dominion Copper Mining & Smelting Co., Globe, Ariz., reports a production of 30,210,361 lb. of copper, 148,459 oz. of silver and 3308 oz. of gold from ores smelted in 1914. Of this production, 17,816,284 lb. of copper, 33,311 oz. of silver and 602 oz. of gold came from Old

Dominion ores and the remainder from custom ores. The total amount received for the metals from company ore was $2,473,582; the profits from the treatment of custom ores, $200,623, and the total receipts, $2,674,205. Expenses at Globe were $1,431,654, and refining, commissions, transportation, taxes and other expenses were $264,042, making the total expenses $1,695,696. The net earnings for the year were $978,509. Depreciation on plant amounting to $570,750 is not included in the figures just given. Dividend payments were $445,500, making total dividends to date $3,807,000. The mines produced 129,813 tons of ore, averaging 7.44 per cent. copper, and the mining cost was $5.20, compared with a cost of $4.78 in 1913. Development work totaled 15,665 ft. The average flow of water in the mine was 3,350,000 gal. per 24 hr. Power costs for 1914 were $68.81 per hp.-year, compared with $71.02 per hp.-year in 1913. The concentrating plant treated 151,893 dry tons of ore averaging 4.67 per cent. copper at a cost of 93.2c., compared with a cost of 87.8c. in 1913. Deducting oil-flotation experimental expense in 1914, however, the cost of concentration was about the same as during the previous year.

California.—During 1914 the production of copper in California amounted to 29,515,488 lb., which is less than that state has produced for several years. The decrease is chargeable to the effects of the European war. The copper mining and smelting situation in Shasta County in the first quarter of the year showed a decided improvement over 1913 conditions, but as the price of copper fell and the bottom dropped out of the market, operations were greatly hampered.

During the first part of the year the Mammoth Copper Co., of Kenneth, acquired by purchase two large groups of copper claims, the Spread Eagle and Stowell groups, and took purchase options on others, the total area amounting to 1500 acres. During the late summer and fall the Mammoth's production fell off about one-third by the shutting down of one of the three furnaces at the smelter. The farmers of Shasta County have renewed their efforts of last year to close the Mammoth smelter, a suit having been filed in the U. S. District Court in November, but no action was taken by the court up to the close of the year. The opposition on the part of the farmers has kept all the development companies practically at a standstill, except the Mammoth, as they did not feel justified in expanding their operations until some definite decision had been reached insuring freedom to continue smelting works without fear of being enjoined. The recent expansion of the Mammoth is taken as a good sign that the trouble is practically at an end, and it is said that some of the farmers have admitted that no recent damage has been done to the trees and crops.

A large amount of development has been done on the properties taken over by the Mammoth and some ore has been found. The Spread Eagle and the Stowell have been diamond drilled and also developed by tunnels. Diamond drilling has also been done on the Keystone and the Shasta Copper Exploration Co. properties. The Stowell has a 1200-ft. tunnel; the other tunnels are shorter. The Mammoth Co. will build a wagon road to the Spread Eagle and will probably install a compressor during this year. All of these properties purchased and under option to the Mammoth are situated between the Balaklala and the Iron Mountain mines. One group of Trinity Copper Co. properties lies between the Spread Eagle and Iron Mountain; the other lies north of the Balaklala. The Golinsky lies east of the Mammoth's Backbone group. Both the Trinity Copper Co. lower group of mines and the Golinsky mines have been developed to a point where production waits only an active mining and reduction of the ores. During the past 3 years the Shasta Copper Exploration Co. has done a large amount of exploration and development on the West Side, and has kept the section alive by persistent exploiting against the strong odds that the farmers might succeed in killing the copper-mining industry in Shasta County.

Idaho.—The annual report of the State Inspector of Mines, Mr. R. N. Bell, for the year 1914 shows the copper production of Idaho for the last 5 years to be as follows:

	Pounds.
1910	5,837,639
1911	3,962,060
1912	7,392,280
1913	8,627,242
1914	5,178,000

The principal producing mines are in Shoshone and Custer Counties, and with the rich ore-body of the Snowstorm mine, which was the only important copper producer in Shoshone County, now completely mined out, the copper output of the state will come chiefly from Custer County.

In the Snowstorm mine above Mullan, the stoping ore became exhausted in September and mill operations were suspended. The fault which cut out the ore on the No. 3 tunnel level, it is said, has been partly overcome by the discovery of the vein below the fault, and present indications are favorable to the recovery of the original ore-body in this deep development.

The National mine, between the Snowstorm and the town of Mullan, completed a magnificent modern concentrating mill of 500 tons daily capacity, and was in shape to operate its magnificent resources of copper concentrating ore when war was declared in August and cut off the market for its product, since which time the enterprise has been shut down and remained idle.

Custer County Mines.—At Mackay the Empire Copper Co.'s market for ore was shut off during the summer by the war, but a full complement of lease operations has since been continued by the company, giving employment to a force of over 60 men, and when visited last fall the many interesting phases of this company's group of mineral claims was showing the usual rich promise of continued production when a market is afforded. This company is pushing a deep tunnel that will undercut the main deposits nearly 1000 ft. below the present lowest level. This tunnel has already attained a length of between 3000 and 4000 ft. and will probably be driven into the main ore zone within another year, and has every promise of disclosing a greatly expanded tonnage of profitable copper ore. This company is also planning the erection of a Christensen process mill with which to treat its extensive body of low-grade mineral on the ground that will not stand present shipping charges.

Michigan.[1]—The year 1914 was a most trying one for the Lake Superior copper district. The companies and employees were just getting nicely squared away from the effects of the strike of the Western Federation of Miners when the European war broke out, demoralizing the copper market and forcing a general curtailment of the working forces and a lowering of wages.

The strike was officially called off in April. Although the mines had been working at full force for some months previous to this, it had cost a lot of money, and during the early part of the year production was practically suspended, so that at the outbreak of the war the companies were not in good financial condition to withstand this serious handicap. A general reduction of 10 per cent. was made in wages, and the Calumet & Hecla Mining Co. and subsidiaries went on three-quarter time Sept. 1, and the Copper Range mines on half time, working 2 weeks and shutting down completely for the remaining 2 weeks in each month. A number of the smaller companies suspended operations completely, and as a result there were a number of unemployed men throughout the district. Production was reduced in about direct proportion, with the exception of a possible slight increase in the efficiency of the working force and a little larger production per man employed.

The production of copper in Michigan during 1914 was 158,009,748 lb., as compared with 155,715,286 lb. in 1913.[2] In the following tables the production of the principal companies and the dividends for the last few years are given.

[1] Mining notes by C. L. C. Fichtel, *Eng. Min. Jour.*, Jan. 9, 1915.
[2] Advance statement, U. S. Geol. Surv.

COPPER PRODUCTION IN MICHIGAN
(Pounds of fine copper)

Mines.	1906.	1907.	1908.	1909.	1910.	1911.	1912.	1913.	1914.
Adventure...	1,552,628	1,244,872	90,870	*Nil*	*Nil*	*Nil*	8,727,312	.....	.....
Ahmeek.....	3,077,507	5,527,672	6,280,241	9,198,110	11,844,954	15,196,127	16,455,769	9,220,874	13,643,605
Allouez	3,486,900	2,934,116	3,047,051	4,031,532	4,655,702	4,780,494	5,525,455	4,091,129	6,056,548
Atlantic.....	1,439,082	*Nil*	*Nil*	43,483	19,018	*Nil*	*Nil*	44,370	.....
Baltic.....	14,397,557	16,704,868	17,724,854	17,817,836	17,549,762	15,370,449	13,373,961	7,736,124	7,001,945
Cal. & Hecla.	94,529,821	88,055,723	81,660,723	74,593,553	72,672,469	72,861,925	67,856,429	45,016,890	53,691,562
Centennial...	2,253,015	2,373,572	2,196,377	2,583,793	1,572,566	1,493,834	1,742,338	1,612,262	2,287,532
Champion...	16,954,986	16,489,436	17,786,763	18,005,071	19,224,124	15,639,426	17,225,508	12,080,592	15,807,206
Franklin	4,571,570	4,401,248	3,703,421	1,615,556	966,353	820,203	1,710,651	1,021,440	.....
Isle Royale..	2,937,098	2,667,608	3,011,664	5,719,056	7,567,399	7,490,120	8,186,957	4,158,584	6,593,451
Mass.....	2,106,739	2,078,677	1,766,930	1,723,436	1,321,885	1,326,898	2,045,006	1,213,545	2,944,952
Michigan....	2,875,341	2,665,404	3,000,206	1,979,305	36,682	327,773	300,000	.....	.....
Mohawk.....	9,352,252	10,107,266	10,295,881	11,248,474	11,412,066	12,091,056	11,995,598	5,778,235	.....
Osceola.....	18,588,451	14,134,753	21,250,794	25,296,657	19,346,566	18,388,193	18,413,387	11,325,010	14,970,737
La Salle.....	.....	.....	.....	.....	.....	.....	.....	287,200	.....
Quincy.....	16,194,940	19,796,058	20,600,361	22,511,984	22,517,014	22,252,943	20,634,800	12,184,128	.....
Superior	.....	.....	21,244	1,789,315	3,181,041	3,236,233	3,921,974	2,992,765	3,217,633
Tamarack...	9,832,644	11,078,604	12,806,127	13,533,207	11,063,606	7,494,077	7,908,746	4,168,743	1,074,808
Trimountain	9,507,933	8,190,711	6,034,908	5,282,404	5,694,868	6,120,417	6,980,713	4,990,938	5,048,306
Winona.....	278,182	1,285,863	*Nil*	*Nil*	*Nil*	*Nil*	2,307,237	1,448,737	1,352,084
Wolverine...	9,548,123	9,273,351	9,555,233	9,971,482	10,469,253	9,630,639	9,408,960	1,550,000	.....
Victoria.....	.....	1,207,237	1,290,040	1,164,564	1,164,564	1,303,331	1,224,911	4,488,000	.....
Others.....	.....	100,000	.....	2,862,233	899,647	294,873	.....	.....	.....
Totals	224,071,103	220,317,041	222,123,688	230,971,051	223,179,539	216,119,011	225,945,712	.....	.....

DIVIDENDS PAID BY MICHIGAN MINES

Mine.	1912.	1913.	1914.	Mine.	1912.	1913.	1914.
Calumet & Hecla	$4,200,000	$3,200,000	$1,000,000	Quincy ...	$550,000	$412,500	$55,000
Copper Range Con....	2,100,000	1,082,700	.....	Tamarack.	.....	.....	.....
Mohawk.....	350,000	500,000	100,000	Wolverine	550,000	300,000	240,000
Osceola.....	1,153,800	1,009,580	288,450	Totals....	$8,903,800	$6,504,780	$1,683,450

The Keweenaw Copper Co. carried on development work at the Phoenix property on the Ashbed lode; the shaft was put down several hundred feet and drifts extended from the various levels. The formation is flat and comparatively wide, and the copper contents most encouraging. The Wolverine and Mohawk properties were operated full time during the latter part of the year when the other mines were working at reduced time. This was consistent, because the output of these mines is taken for trade in the United States.

The Tamarack Mining Co. completely suspended operations at the mine, with the exception of pumping. Plans were laid for working over of the tailing piles and a large structural-steel building is about completed, which will be used for a regrinding and concentrating plant. This plant when completed will contain 32 Hardinge mills.

The Calumet & Hecla Mining Co. put into commission its electrolytic plant at Hubbell and discontinued the Black Rock smelting works at Buffalo, and is treating all the electrolytic copper for its mines and subsidiaries at this plant.

The first portion of the No. 2 re-grinding plant, consisting of 16 Hardinge mills together with their complement of tables, went into commission during the summer. The 20-in. hydraulic dredge that will be used in the reclamation of the tailing piles was completed and given a trial run, and worked well. All construction work was stopped at the outbreak of the war and nothing further was done toward the completion of this plant. The company laid plans for a leaching plant and the excavations were started, but this also was stopped and the contract for the structural steel was canceled. A central employment bureau was established through which all the men for the Calumet & Hecla plants and all subsidiary companies will be handled.

The Osceola Consolidated Mining Co., Houghton, Mich., reports a production of 14,970,737 lb. of copper for 1914, which was sold for an average of 13.14 cts. per lb., making total receipts $1,967,725. Expenses were $1,615,139 and consisted of $1,425,205 for mining, milling and transportation, $21,109 for construction, $167,734 for smelting, freight, commissions, etc., and $1091 for interest. The net profit for the year was $352,786 and dividend payments totaled $288,450, leaving $64,136 to be added to surplus. Total dividends to date amount to $12,179,675.

There was 1,136,118 tons of rock hoisted, of which 2.436 per cent., or 27,671 tons, was discarded as waste. The mill treated 1,108,447 tons, yielding 20,997,900 lb. of mineral which yielded 71.296 per cent. refined copper. This is equal to a yield of 13.5 lb. of refined copper per ton of rock treated.

The Osceola company started work on the foot-wall formation at the main mine and had a new shaft house nearly completed at the No. 3 shaft, which has been idle for a number of years, when the curtailment went into effect. Nothing was done at the Laurium property during the year and the La Salle company suspended operations, as did also the Hancock, with the exception of pumping.

The Superior Copper Co. lost the boiler and compressor house at its No. 1 shaft through fire, which necessitated the shutting down of the mine for about 3 weeks.

The Copper Range Consolidated Mining Co. carried on normal operations until about Sept. 1, when it went on half time. During the year, one of the largest masses of copper discovered in the district has been uncovered in the Trimountain mine; it was first encountered between the 24th and 25th levels and has been uncovered down to the 27th level and extends along the lateral for about 40 ft. with an average thickness of about 8 in.

The annual report shows an income for the year 1914 of $494,600, as compared with $490,536 for 1913. The production from which earnings

were derived was 19,953,854 lb. of copper, obtained from the Baltic, Trimountain, and one-half of Champion. The average cost was 10.661 cts. per lb., compared with 11.71 cts. for the previous year. The average yield of copper per ton of rock for all of the mines was 21.95 lb., compared with 25.24 lb. in 1913.

The report of the Mohawk Mining Co., Mohawk, Mich., for 1913, shows a production of 5,778,235 lb. of copper, which was sold at an average price of 15.36 cts. per lb. The production in 1912, before the strike, was 11,995,598 lb. The profits for 1913 were $123,839, compared with $656,435 for 1912. After paying dividends amounting to $500,000, a surplus of $521,155 was on hand at the end of the year. There was 395,100 tons of rock hoisted, of which 7.2 per cent. was discarded as waste, leaving 366,458 tons treated, which produced 8,018,000 lb. of mineral or 5,778,235 lb. of refined copper. This gives a yield of 15.67 lb. of copper per ton of rock stamped. The total cost of producing copper was 13.22 cts., made up as follows: mining and milling, including transportation, 10.42 cts.; smelting, freight, and marketing product, $1.16 cts.; construction and strike expense, 1.64 cts. per lb.

The Winona Copper Co., Houghton, Mich., showed net assets over liabilities on Jan. 1, 1915, of $92,649, of which $37,462 consisted of unpaid assessments. Rock stamped in 1914 amounted to 123,339 tons, from which 2,239,170 lb. of mineral was produced. This, when refined, yielded 1,352,084 lb. of copper. This is equivalent to 18.15 lb. of mineral and 10.96 lb. of copper per ton of rock stamped. There were 771,442 lb. of copper sold at 14.2 cts. per lb., and 580,643 lb. remained unsold. The mine was shut down in August, after reaching the greatest monthly output in its existence in July, and remained closed until October, when 35 of the best workmen resumed work on a tributing arrangement, by which the company receives 50 per cent. of the returns over the wages.

The Allouez Mining Co., Calumet, Mich., for 1914 reports a profit of $114,530 from a production of 6,056,548 lb. of refined copper sold at 12.853 cts. per lb. Silver sales amounted to $13,402, making total receipts $791,821. Expenses for operations were $672,114, and interest payments, $5176. From 354,457 tons of ore stamped 9,408,470 lb. of mineral was obtained, which contained 64.37 per cent. of refined copper. The yield per ton of rock stamped was 17.09 lb. of copper. The cost of producing copper during the year was 11.18 cts. per lb.

The White Pine Copper Co. in Ontonagon County, which is under the control of the Calumet & Hecla Mining Co., carried on operations throughout 1914 in a consistent manner. Two shafts were opened and the formation developed was rich. A 1000-ton mill is in course of erection and will go into commission in 1915.

Missouri.—During 1914 Missouri produced 53,519 lb. of copper derived mainly from the dressing of lead concentrates from mines in the southeastern part of the state. The only mine reporting production of copper ore was the Swansea mine, in St. Genevieve County, which produced oxidized ore carrying copper and silver.

Montana.—Montana ranks second among the states in magnitude of production for 1914, the output for the year being 236,805,845 lb.,[1] as compared with 285,718,918 lb. in 1913. Most of Montana's production comes from the Butte district, which produced about 283,600,000 lb. in 1913, and 223,720,000 lb. in 1914. The largest single producer is the Anaconda Copper Co. whose output for last year was 205,298,531 lb., and for 1913 was 270,301,644 lb.

According to the annual report of the Anaconda Copper Co., the mines of the company did 33.15 miles of development work and, in spite of the interruption caused by labor troubles, the ore reserves were increased by a tonnage slightly in excess of the ore extracted during the year. The mines produced during 1914—3,898,100 tons of ore, and 6782 tons of precipitates, making a total of 3,904,882 tons.

The reduction works treated a total of 3,748,726 tons of ore and other cupriferous material at Anaconda, and 488,243 tons at Great Falls. The results of these operations were as follows:

	Lb., Copper.	Oz., Silver.	Oz., Gold.
Smelter	188,664,551	7,555,915	78,815
Anaconda	35,055,741	758,200	20,835
Great Falls			
Total	223,720,292	8,314,115	99,650

At the Washoe smeltery the round-table plant was completed early in the year, and was successfully operated during the entire remainder of the year. The results exceeded all expectations, not only as to per cent. of recovery, but also as to the copper contents of the concentrates. Work upon the 2000-ton leaching plant was carried on without cessation, and it is expected to be completed by May, 1915, and will treat the sand tailings which have accumulated from the operations of former years, amounting to many millions of tons. This plant when operating will produce about 700,000 lb. of copper per month at a very low cost. The 100-ton acid plant will be completed by May, 1915, and its entire output will be used in the leaching plant. One reverberatory furnace was equipped with coal-dust-firing apparatus, and tests were made with different grades of coal, with such good results that the entire plant will be remodeled and operated with pulverized coal. The benefits which it is expected will result from this kind of practice will very materially affect the cost of production, as a much heavier charge per furnace will

[1] Advance statement, U. S. Geol. Surv.

be treated, with a much lower coal ratio than before. The blast-furnace department will be maintained in its present good condition for use in case of emergency or for increasing the production. A new roaster plant consisting of 40 furnaces will also be installed. The converter department is to be equipped with the Great Falls type of cylindrical converters, 20 ft. in diameter, and a reverberatory furnace is to be built for use in cleaning the slag from the converters.

At the Great Falls smeltery it is planned to abandon the blast-furnace practice, and to treat in coal-dust-fired reverberatories the concentrates shipped from Anaconda. The new reverberatory furnaces will be built during the year 1915. The present antiquated electrolytic refinery is to be replaced with a modern plant having a capacity of 10,000,000 lb. per month. These improvements, it is estimated, will cost in the neighborhood of $2,000,000.

The shafts of the different properties were sunk during the year to additional depth aggregating 3460 ft., and extensive repairs were made in the shafts of the Mountain Consolidated, Diamond, Steward, and Montain View properties. The Never Sweat mine was not operated during the year, and all work on the Nettie and Tropic mines was discontinued early in August. Development work was especially satisfactory in the Leonard, West Colusa, Steward, Original, Tramway, Anaconda, Badger State, and West Gray Rock mines.

During the year the North Butte Mining Co. shipped 343,314 wet tons of ore, and 71 wet tons of precipitates, to the Anaconda smelter. This ore produced 18,421,761 lb. of copper, 1,092,300 oz. silver, and 1107 oz. of gold. The total earnings of the company were $3,084,774, and the net income was $358,215. In order to block out the company's mining properties, there were purchased during the year additional interests in the Lillie May and Sunset lode mining claims, and the entire interest in the King fraction claim, and a small silver fractional claim, adjoining the company's original mining properties in the West Side mineral district. In the Butte East Side mineral areas additional interests were purchased. Looking toward the erection of a plant in which to treat the ores of the company, suitable ground with ample water right has been purchased.

In 1914 the East-Butte Copper Co. worked only 220 days, being idle from August 8 to the end of the year. While in operation the yield was greater than in the previous year. Development in the Pittsmont mine totaled 4814 ft. The main shaft was sunk from 1585 to 1770 ft. In the upper levels a large tonnage of new ore was opened up. The company treated 110,992 tons of ore, from which 9,175,579 lb. of copper, 242,437 oz. silver, and 2219 oz. of gold were extracted.

The report of the Tuolumne Copper Mining Co. states that the ore

mined during 1914 averaged 4.1 per cent. copper, and produced 1,945,286 lb. of copper, 115,355 oz. silver, and 150 oz. of gold. The net return on these metals amounted to $133,515. Work was stopped on Oct. 24, on account of the market conditions.

Nevada.—As a result of the curtailment of output made necessary by the war the production of copper in Nevada during 1914 decreased from 85,209,536 lb. in 1913 to 60,122,904 lb.[1] The bulk of Nevada's copper output comes from the operations of the Nevada Consolidated Copper Co. at Ely. During the last 5 months of the year that company operated on a 50 per cent. basis, and the decrease in the state's yield in copper is thus largely accounted for. The Nevada Consolidated began producing in 1908, and up to the close of 1914 the total output of blister copper amounted to 166,447 long tons,[2] or 372,842,240 lb.

Copper production of the Nevada Consolidated Copper Co. for 1914, according to the company's annual report, was 49,244,056 lb., which was sold at 13.396 cts. per lb., compared with 69,972,829 lb. at 14.879 cts. the previous year.

Production for the first half of the year, according to President Eccles, was lower than during any previous period since 1909, when the plant was completed for full operations. This was due to the necessity of mining, during the second quarter of the year, a very large tonnage of low-grade ore averaging only 1.1 per cent. copper. This was necessary in order to secure the best conditions in the pits for future operations. Average grade treated during the year was consequently reduced, being 1.483 per cent. copper, *versus* 1.599 per cent. for the preceding year.

Cost of producing after crediting all miscellaneous earnings, but before providing for plant and equipment depreciation, was 8.91 cts. per lb., *versus* 8.68 cts. for the previous year. Including plant and equipment depreciation and charges of every character, except ore extinguishment, this is increased to 9.82 cts. per lb., as compared to 9.51 cts. for the year ended Dec. 31, 1913.

During the year prospecting to develop additional ore was systematically carried on with the result that 4,552,000 tons, averaging 1.87 per cent. copper, was added to available ore reserves. There was milled during 1914, 2,640,294 tons averaging 1.483 per cent. copper, leaving 41,020,296 tons of ore, averaging 1.68 per cent. copper, in reserve Dec. 31, 1914, as compared with 39,108,590 tons, averaging 1.65 per cent. Dec. 31, 1913, an increase of 1,911,706 tons. There still remains in reserve more developed ore than at the end of any previous fiscal year.

From the beginning of operations in July, 1908, to Dec. 31, 1914, a period of 6½ years, 14,917,287 cu. yd. of overburden has been removed

[1] Advance statement, U. S. Geol. Surv. [2] *Salt Lake Min. Rev.*, Jan. 15, 1915.

in uncovering the ore-body, 15,391,491 tons of ore has been milled, 355,287,601 lb. of refined copper produced, and $14,977,250 has been paid in dividends.

Several months ago the Nevada Consolidated absorbed its subsidiary, the Steptoe Valley Smelting & Mining Co., which owned the reduction works at McGill, and all business is now done in the name of the parent company. Milling operations at McGill now handle an average of 5000 tons of ore a day through the concentrator, where more than 12,000 tons has been milled in 24 hours at times in the past.

For some months past considerable attention has been devoted to experimenting with an oil flotation process and with encouraging results. While the saving of values by the ordinary concentration processes used is generally less than 70 per cent., it is understood that the oil process has been perfected on a small scale, so that a much greater percentage of the values can be saved. Steps are now being taken to experiment with the oil process on a larger scale, while the curtailment in output by the company makes part of the concentrator building available. It is believed that if the oil process can be successfully demonstrated on a large scale, it will be adopted in the near future as the means of obtaining greater profits for the company shareholders.

Next to the Nevada Consolidated in importance in the Ely copper district is the Consolidated Coppermines Co. This is a merger of the Giroux, Butte and Ely, old Coppermines and Chainman Companies, and when all the details of the consolidation are completed, the Coppermines will be the largest company in point of holdings. It will own 2741 acres of mining claims in the Ely district, and 3085 acres of ranch lands, together with valuable water rights.

The chief work of the Consolidated Coppermines Co. management for the past few months has been the development necessary to putting into sight ore reserves, which on April 30 last were reported at 21,624,236 tons of 1.153 per cent. copper. Substantial tonnages have since been added to reserves, although not sufficient to warrant erection of a mill.

It is understood that the mine management has set upon 40,000,000 tons as a minimum tonnage upon which to base mill construction, and indications now point to the putting into sight of that amount before the end of the summer.

According to the annual report of the Mason Valley Mines Co., the total tonnage of ore smelted during 1914 was 142,197 tons, of which 75,038 tons was from the company's property, and 67,159 tons was custom ore. From this ore there was produced and shipped 212 tons of copper matte, and 4542 tons of blister copper, containing 9,127,974 lb. of copper, 11,553 oz. gold, and 221,151 oz. of silver.

The smelter was in continuous operation from Jan. 6 until it was shut down on Oct. 20, on account of insufficient ore supply. The smelter could not be economically operated on the ores of the company alone, and after the ore and by-products had all been put through, the plant was closed. The only addition to the smeltery was the completion of the converter plant, which was started Jan. 3, 1914, and ran until the plant was shut down in October. A large saving in treatment charges and freight was made as a result of the operations of the converter plant, which produced blister copper for direct shipment to the eastern refineries, and permitted the treatment of a larger tonnage of siliceous ores than was possible before its installation.

New Mexico.—The production of copper in New Mexico during 1914 amounted to 64,204,703 lb.,[1] as compared with 50,196,881 lb. in 1913, which is an increase of nearly 28 per cent. As heretofore, the greatest copper output of the state comes from the porphyry ores of the Chino Copper Co. in the Santa Rita district. This company was producing at the end of the second quarter at the rate of 6,000,000 lb. per month from the treatment of about 6460 tons of ore daily. On account of the war the output was reduced almost one-half during the latter part of the year. During the first 7 months of the year all 5 sections of the present milling plant were in operation 95 per cent. of the possible time, averaging 1345 tons per section daily, while during the last 5 months the daily tonnage for each section was 1085. The mill treated during the year 1,907,300 dry tons of ore, averaging 2.1151 per cent. copper. The total production of concentrates was 147,925 tons, containing an average of 18.505 per cent. copper, or 54,748,254 lb.

The production of copper contained in concentrates for the year, together with that contained in crude ore shipped during the year, was as follows:

	Pounds.
Total production from concentrates	54,748,254
Additional production from direct shipping ore	2,093,723
Total production from both sources	56,841,977

The average cost of net copper produced from concentrates, after making deductions for smelter allowances and crediting gold values, was 7.60 cts. per lb., as compared with 8.787 cts. for the previous years.

The total amount of ore and waste moved by steam shovels during 1914 was 4,192,009 cu. yd. of material in place. Of this amount 3,173,717 yd. was stripping, and the remainder, equivalent to 2,114,910 tons, was ore. Approximately 185,000 tons was added to the stock pile for the principal reason that it was in the form of large boulders, the breaking of which, before the completion of the new crushing plant, to a size that

[1] Advance statement, U. S. Geol. Surv.

could be conveniently received at the mill, involved too much delay and expense. Ore shipments direct to the smelter amounted to 19,405 tons. The remainder of the ore mined, amounting to a little over 1,910,000 tons, was delivered to the mill.

The average cost for steam shoveling and removing all classes of material during the year was 36.52 cts. per cu. yd., being a decrease of 0.35 cts., as compared with the previous year. The cost of handling waste alone is equivalent to 16.12 cts. per ton, while the cost of ore production alone was 22.13 cts. per ton. The cost of handling waste alone was 0.04 cts. per solid yd. higher than for the previous year, while the cost per ton of ore was 1 ct. less than for 1913. The decreased cost of handling ore as compared to that of the previous year, in spite of the fact that the property was running under restricted output for 5 months, is due in great measure to the benefit derived from the primary crushing plant, permitting a greater efficiency at the shovels.

The total tonnage previously estimated was 93,840,812 tons of 1.77 per cent. copper. The increase, due to the additional ore disclosed by the subsequent drilling, was 1,463,840 tons of 1.47 per cent. copper, giving a grand total of 95,304,652 tons of 1.76 per cent. Since the starting of the mill in 1911 and up to Jan. 1, 1915, there has been treated a total of 5,012,800 dry tons of ore. An additional 21,697 tons of ore was shipped direct to the smelter, making a total of 5,012,800 dry tons of ore mined and disposed of to Jan. 1, 1915, and containing an average of 2.09 per cent. copper. Deducting this from the calculated ore reserves as stated, leaves 90,270,150 tons of ore, averaging 1.75 per cent. copper still available in the fully developed ore-bodies.

The next most important copper operation is that of the Burro Mountain Copper Co. at Leopold. Here development was in progress during the year, and flotation experiments were carried out at the experimental mill at Tyrone, with which the mine is connected by a standard-gauge road and transportation tunnel. Construction of the central power plant, and mine development continued throughout 1914. Near Lordsburg, the 85 Mining Co. and the Bonnie shipped, and some oxidized copper ore was sent to El Paso from the Apache district, near Hachita.

In the Mogollon district, more ore was mined in 1914 than in any previous year; about 120,000 tons was treated by the three mills, the Socorro, Ernestine and Deadwood; a few minor shipments of high-grade ore were made direct to smelters from the Pacific and Eberle mines. The Socorro Mining & Milling Co. was especially active in the development of new properties, having purchased 20 of the Johnson claims from the Oaks company and optioned the Pacific and the Deep Down groups. The

Ernestine company operated about as usual and completed an elaborate geological survey. The Alberta Development Co. and the Precious Metals Exploration Co. became producers, and the Oaks company added another mine, the Eberle, to the list. The Lincoln and the Mogollon Gold & Copper Co. were active part of the year.

Tennessee.—The production of copper in Tennessee during 1914 amounted to 18,661,112 lb.,[1] as compared with 19,489,654 lb. the previous year. The entire output of copper comes from the Ducktown district, Polk County, in the southeastern part of the state. There are two operating companies, the Tennessee Copper Co., and the Ducktown Sulphur, Copper, and Iron Co., and the yearly output of the state is divided between the two companies. In 1914 the Tennessee Copper Co. produced 12,871,113 lb. of copper, as compared with 13,493,140 lb. in 1913. That company also produced 210,163 tons of sulphuric acid. Ore reserves are estimated at 4,010,661 tons, exclusive of the Eureka ore-body.

The report of the Tennessee Copper Co., Copperhill, Tenn., for 1914 shows a production of 12,871,113 lb. of refined copper from 485,051 tons of company ore smelted. Net profits for the year, including acid-plant earnings and earnings from all other sources, amounted to $751,893.

This amount was distributed as follows: Dividends, $600,000; reserve for general depreciation, $100,000; reserve for Federal income tax, $1126; and addition to surplus account, $50,767. Dividends to date aggregate $4,465,250. A record of the production from the company's ore for 1901 to 1914 inclusive shows that $4,978,349 tons of ore has been mined, 4,961,673 tons smelted and 155,493,546 lb. of copper produced. Ore reserves are estimated to contain 5,390,661 tons averaging 26.54 lb. of recoverable copper.

The total cost of producing refined copper was 11.40c. per lb., not crediting the sales of sulphuric acid nor the values of copper in flue dust. The acid plant produced 210,163 tons of 60° Baumé acid. The smelting plant treated 724,822 tons of ore and flux with 38,726 tons of coke.

Utah.—The copper production of Utah during 1914 increased from 148,057,450 lb. in 1913 to 160,589,660 lb.,[2] notwithstanding the depression in the copper industry as a result of the war. This increase came chiefly from the porphyry ores. By far the greater part of Utah's output of copper comes from the Bingham district, and the bulk of that from one mine, the Utah Copper Co. Thus, of the output of 1913, 144,920,000 lb. is credited to the Bingham district, and about 120 million lb. to the single largest company operating there. Of the entire output of the state during the past 44 years, about 50 per cent. was produced

[1] Advance statement, U. S. Geol. Surv.

[2] Advance statement, U. S. Geol. Surv.

from the property of this one company in the last 10 years, and about 40 per cent. during the last 5 years.[1]

During the first half of the year, the Bingham mines were producing at a rate considerably above that of the previous year, the output for the first 7 months totaling 5,896,335 tons of ore, as compared with 5,164,603 tons during the corresponding months in 1913. The total tonnage for the year was about 8,078,000, as compared with 9,190,374 tons in 1913.[2]

The report of the Utah Copper Co., Bingham, Utah, for 1914 shows a production of 115,690,445 lb. of copper, 34,729 oz. of gold, and 325,351 oz. of silver. The net yield of the ore milled was about 17.8 lb. of refined copper per ton. The total value of gold and silver contents was $875,303. Dividends amounting to $4,827,885 were paid during the year, which brings the total dividend payments of the company up to $25,817,815. The report shows a net profit of $6,789,532 from the year's operations and income from investments; but of this amount only $5,379,637 was actually available for dividends, as will be seen by the analysis of the financial statements which follow. The yield of the ore in 1914 was higher than for the previous year, as is shown by the accompanying statement of production for the last 5 years:

UTAH COPPER CO. PRODUCTION FOR LAST FIVE YEARS

Year.	Tons of Ore Treated.	Yield, Lb. Cu per Ton.	Total Copper Produced, Lb.	Total Value of Gold and Silver Produced.
1910	4,340,245	19.46	84,502,475	$1,001,089
1911	4,680,801	19.95	93,514,419	999,622
1912	5,315,321	17.2	91,366,337	873,995
1913	7,519,392	15.2	113,942,834	732,583
1914	6,470,166	17.8	115,690,445	875,303

The total outstanding stock of the company now amounts to 1,624,490 shares. There was an increase of 40,810 shares, which were exchanged for the bonds of the Bingham & Garfield Railroad. A stock dividend was received from the railroad amounting to 15,055 shares; so that now the Utah Copper Co. owns the entire capital stock of the railroad company.

From data obtained in 1914 it was estimated that the capping over the ore-body averaged 115 ft. in thickness. A total of 5,708,836 cu. yd. of stripping was removed during the year, making a total of 27,834,043 cu. yd. of capping removed to date. Stripping operations were extended to an additional 20.5 acres during the year, making a total of 191.63 acres over which stripping operations have been carried on. The total area completely stripped at the end of the year was 76.33 acres. With an average thickness of 115 ft. there are 185,533 cu. yd. of stripping per acre; therefore the stripping to date is equivalent to completely stripping 150

[1] D. C. Jackling, Review of the Mining Industry of Utah, *Salt Lake Min. Rev.*, Sept., 1914.
[2] *Salt Lake Min. Rev.*, Jan. 15, 1915.

acres. It is estimated that the area over which stripping has been completed, or partly completed, contains an average of about 1,558,000 tons of ore per acre, and that the capping removed is equivalent to the complete stripping of 233,700,000 tons of ore. Of this quantity 35,190,400 tons, or about 15 per cent., has been mined. The ratio of stripping to ore is about 1: 4, or about 1 cu. yd. to 8 tons of ore. Of the ore produced 98.27 per cent. was mined by steam shovels. The average cost of steam-shovel mining was 30.96 cts. per ton, of which 8.34 cts. represented charges for stripping and development. The combined cost of surface and underground mining was 32.32 cts. per ton, of which 9.2 cts. was for prospecting with churn drills and for development, 7.5 cts. for stripping expense, and a working cost of 23.12 cts. per ton.

During the year, the mills treated 6,470,166 tons of ore, of which 4,461,461 tons was treated at the Magna plant and 2,008,705 tons at the Arthur plant. The average grade of the ore milled was slightly under 1.425 per cent. copper. The average mill recovery at both plants was 66.04 per cent., as compared with 63.95 per cent. in 1913. The milling cost at the Magna plant was 34.35 cts. and at the Arthur plant 37.55 cts. per ton. The average cost at both plants was 35.36 cts. per ton. The average grade of concentrates was 18.19 per cent. The average cost of copper as reported after deducting gold and silver credits, but not miscellaneous income, was 8.131 cts. per lb. The average total cost of mining and milling, exclusive of transportation charges, was 67.68 cts. per ton.

In 1914 there was 8920 ft. of drill holes completed, which makes the total amount of all drill holes to date 46,391 ft., or an average of 552 ft. per hole for 67 churn-drill holes and seven diamond-drill holes. Ore reserves are estimated to contain 342,500,000 tons of ore, averaging 1.45 per cent. copper. In determining the grade of the ore there were used 56,714 assays, representing 334,518 ft. of development work.[1]

The Bingham Mines Co., Salt Lake City, Utah, reports earnings of $172,530 for 1914. Of this $60,280 came from the earnings of the Dalton & Lark and Commercial mines of Bingham, Utah, and $104,250 from dividends received from the stock of the Eagle & Blue Bell, of Tintic, Utah, owned by the company. The operating statement of the Dalton & Lark and Commercial mines shows a production of 49,780 dry tons of ore, having a gross value of $291,787, from which $80,490 was deducted by the smelters for freight, sampling, assaying and smelting. The net smelters' returns were $211,297. The metal contents of the ore were 1,110,762 lb. copper, 3613 oz. gold, 188,905 oz. silver, and 3,738,773 lb. of lead.

The Utah Consolidated Mining Co., operating the famous Highland

[1] *Eng. Min. Jour.*, May 8, 1915.

Boy mine, had a very successful year. Dividends to the amount of $600,000 were distributed, as compared with $450,000 in 1913. During the year, 209,314 tons of ore was mined, as compared with 262,435, tons for the previous year. Earnings have been favorably influenced by the acquisition, during the year, of the International Smelting and Refining Co. by the Anaconda Copper Co.

The Bingham-New Haven, in Carr Fork, also had a successful year. The tonnage of ore milled was 38,917, concentrates from which came to 15,141 tons. Crude lead ore to the amount of 7270 tons was shipped to the smelter, while shipments of copper ore amounted to 10,586 tons.

An extra profitable year is indicated by the payment of dividends amounting to 75 cts. a share, of which 228,689 have been issued. Development work sufficient to keep pace with the extraction of ore has been carried on, and there appears to be a noticeable improvement in depth, particularly in gold content.

The United States Mining Co., in Upper Bingham, has operated its mines throughout the year with satisfactory results. A total of 193,962 tons of copper, lead, and zinc ore was shipped to the United States Smelting Co.'s plant at Midvale. Of this amount 101,687 tons was copper ore of smelting grade, without concentration.

OPERATIONS OF THE "PORPHYRY" COPPER COMPANIES IN 1914

	Utah.	Ray Consolidated.	Nevada Consolidated.	Chino.	Miami.
Ore reserves, tons	342,500,000	74,765,789	41,020,296	90,270,155	36,500,000
Average content copper, per cent.	1.45	2.214	1.75	1.75	1.85
Ore treated, tons	6,470,166	2,427,700	2,640,294	1,907,300	1,096,633
Average content copper, per cent.	1.425	1.76	1.48	2.12	2.28
Gross copper production, lb.	121,779,401	59,044,700	49,244,056	56,841,977	35,048,445
Average recovery, per cent	66.04	67.88	68.48	67.86	69.93
Average copper in concentrate, per cent	18.19	19.25	66.15	18.50	39.31
Average cost milling, cents per ton	35.36	49.88	.....	55.01	49.96
Cost of copper, cents per lb.[1]	8.131 / 7.245	8.839 / 8.763	10.16 / 9.82	7.68 / 7.35	6.46 / .....
Gold production, oz.	34,729	.....	16,046	.....	.....
Silver production, oz.	325,351	.....	49,631	.....	.....

[1] First figure based on net production after making smelter deductions and applying credit for gold and silver. In second figure credit is applied for all miscellaneous income.

Wyoming.—The output of copper in Wyoming dropped from 362,235 lb. in 1913 to 17,082 lb. in 1914.[1] This small production comes from the Hartville district, chiefly; the Encampment district, and the Casper Mountain district in Natrona County produced a carload each of copper ore. Late in the year work was resumed at the Rambler Copper and Platinum Co.'s property at Holmes, Albany County. The mill was remodeled, and preparations were made to continue operations through the winter.

[1] Advance statement, U. S. Geol. Surv.

Copper Mining in Foreign Countries

Africa.—The output of the copper mines of Africa during the past year has increased somewhat in spite of the disturbing influences of the European war. The production in 1914, according to the figures of Henry R. Merton & Co., as reported in the *Engineering and Mining Journal*, was 24,135 metric tons, as compared with 22,870 tons in 1913. This increase is largely due to the increased output of the Katanga Co.'s mines. The production from the principal districts for the last 4 years is as follows:

AFRICAN COPPER PRODUCTION
(Long tons)

	1911.	1912.	1913.	1914.
Katanga	1,100	2,345	6,790	10,700
Cape Colony	4,480	3,870	3,220	2,420
Namaqua	2,500	2,500	2,500	2,250
Sundries	9,000	7,655	10,000	8,280
Total	17,080	16,370	22,510	23,650

In a circular letter issued by the Union Minière in December an estimate of the year's production was given out, and also a forecast of output for the coming 2 years. The production expected in 1915 is 25,000 tons, and in 1916, 40,000 tons. If these figures are realized the Katanga company will rank with the large copper producers of the world. The company's smelting operations at Katanga have been kept running without interruption, notwithstanding the decline in the price of copper from £60 to £48 per ton. Two furnaces were kept in blast and produced 3730 tons of copper up to the end of November. The third furnace was blown in at the beginning of December in order to increase the output of copper, as a result of the improvement in the price toward the end of the year. The copper produced from the beginning of the year to the commencement of the war was disposed of at a price that netted about £20 per ton, and that sold in London since the shipments to Belgium were interrupted by the war has netted £10 per ton. In order to further increase the output which is being stimulated as a result of the favorable outlook for copper, as shown by the increasing demand and the rise in price, the Katanga company is considering the erection of two additional blast furnaces which have already arrived at Beira, on the east coast.[1]

The Star of the Congo mine, situated 9 miles from the Lubumbashi smelter, produced in 1913, after sorting and washing, 50,000 tons of ore. The mine has been worked for some 3 years as an open cut with hand labor. Most of the ore is soft, but the fluxing dolomitic ore is broken up with 3¼-in. Ingersoll drills. Whites, employing gangs of negroes,

[1] Abstracted from *Min. Jour.*, Dec. 26, 1914.

contract some of the work; about 60 whites and 800 blacks are employed. The ore is now milled through to a haulage level from which the loaded cars are drawn to the adit mouth by cable. The coarse ore is dumped directly into railroad cars, the rest is washed, the coarser being then loaded, the rich middling briquetted, and the "fines" stored for future treatment. Talcose ores are treated in a special washing plant. Since January, 1914, two small Bucyrus steam shovels have, in addition, been stripping overburden and mining soft ore. The buckets are ½ cu. yd. and the shovels have a capacity of 200 tons per 10 hr.

At the Kambove mine, opened in June, 1913, there was produced, after sorting, in the last 6 months of that year, over 11,000 tons of ore. Two steam shovels, one a 48-ton Bucyrus, and the other a Koppel of 49 tons, each with dipper of 1½ cu. yd. capacity, have been shipped and were to have been ready to work early in 1915. Each has a rated capacity of from 500 to 600 tons per 10 hr. The mine is now worked by a main underground haulage-way to which the ore from the surface is shot down chutes. From this the ore is trammed by natives to a loading station, where the hard and soft ore is loaded direct into cars, the slightly cupriferous quartzite, on the other hand, being set aside for later treatment. The ore is sent by railroad to the smelter, where the soft is briquetted. About 30 white men and 400 negroes are employed.

Mining at the Luishia mine was retarded in 1913 by the inadequate labor supply, but nevertheless some 20,000 tons of ore was produced. As it is a powdery ore containing considerable cobalt and iron, the greater portion is briquetted. As the labor supply permitted, development was carried on at several of the mines, the next one to be opened presumably being the Likasie.

As noted above, much of the ore is soft, and to render this a satisfactory furnace product it is briquetted at Lubumbashi. The ore is compressed in a plant consisting of six presses, with a capacity of 250 tons per 20 hr., the pressure being 6·tons to the cu. in. The cylindrical briquettes, which contain no binder, are about 6 in. long and of 4 in. diameter. Concentration of the other ores now consists principally of hand sorting, although some ores are screened and washed, and the talcose ore is treated in log washers. A 50-ton mill is *en route* to Africa, and will be used for mill tests. A third water-jacket furnace was blown in on June 27, and in midsummer the three furnaces were simultaneously in operation, giving a daily production of about 48 tons of ingots, containing from 96 to 97 per cent. copper. It was expected prior to the war that four more would be blown in during 1915, and the two now *en route* and at Beira will presumably soon be erected.

The second battery of 22 Coppée coke ovens was completed in

March, 1914, and now from 3000 to 3500 tons of coke is made from Wankie (Rhodesia) coal. The waste gases are used to heat two Stirling boilers. As a little under 3 tons of coke is used per ton of copper produced, it is evident that these furnaces are sufficient for the present production, although the company also obtains coke from Wankie. A contract made early in the spring of 1914, intended to cover fuel necessary to feed further smelting units, dates from July 1, 1915, and runs 15 years. The coke price is satisfactory and low freight rates have been obtained from the Rhodesian railroads. The copper company engages to take at least 100,000 tons of fuel (at least 40,000 tons of coke, and not over 60,000 tons of coal) per year. The Wankie coal contains about 15 per cent. ash and 2 per cent. sulphur, and is washed to 10 per cent. ash and ¾ per cent. sulphur. The coke recovery is reported to be about 70 per cent. and contains 15 per cent. ash and about 1 per cent. sulphur. Clay and refractory bricks are also obtained at Wankie. Jean Jadot, chairman of the board, states that the cost for 1914 would be about 9.6 cts. per lb., delivered at Antwerp, plus approximately 0.4 cts. for general expenses in Europe. This price of 10 cts., of which 6.7 cts. is for mining and smelting, does not include debenture or amortization charges.

The labor situation is much less critical than a year ago, as late in 1913 a contract was entered into with the Nyasa Consolidated Co. to supply Nyasa natives, and natives are also being obtained from Portuguese West Africa.

The Namaqua Copper Co., operating mines at Concordia, in the western part of the Cape Province, South Africa, has had another successful year. The report for the year 1914 shows that 28,907 tons averaging 5.86 per cent. copper was raised from the Tweefontein mine, 4286 tons averaging 6.56 per cent. copper from the Henderson mine, and 1828 tons averaging 5.16 per cent. copper from the Wheal Julia. The smelter treated 34,871 tons, of which 10,210 tons was briquetted fine, and produced 3808 tons of matte containing 2250 tons of copper. At the leaching plant 113 tons of precipitate containing 78 tons of copper was recovered. The Elmore flotation plant treated 6648 tons of ore and tailing, of an unspecified assay value, for a yield of 530 tons of concentrate averaging 24.75 per cent. copper. The development at the mines has not been encouraging. The ore reserve on December 31 was estimated at 80,875 tons averaging 6 per cent. copper, a fall of 26,017 tons during the year. The accounts show a net profit of £30,070, out of which £23,582 has been distributed as dividend, being at the rate of 12.5 per cent.[1]

In the Transvaal the Messina Copper Co. is the only productive concern, and development operations during the past year have continued

[1] *Min. Mag.*, Apr., 1915.

favorable. The statistics of production of the Transvaal during the last 4 years, as published by the Union Department of Mines, show the rapid growth of the Messina Co. output, as follows:

	Tons.	Value.
1911	2,079	£48,237
1912	1,619	49,142
1913	5,289	138,328
1914[1]	4,046	98,454

Underground the mine continues to open up well. The No. 5 shaft has been sunk to the tenth level, a depth of 1000 ft. The No. 4 shaft, which is a twin vertical of No. 5, is now also being sunk to the tenth level, and when this has reached the same depth as its sister shaft, the No. 5 will be sunk deeper with a view of proving up the lenticular ore-bodies at still greater depth. The question of water supply, which has occasioned the management some anxiety, was solved some little time ago by a very heavy rainfall, and there is now abundant water in the Zand River, from which the company derives its water supply.

The report of the Bwana M'Kubwa Copper Co., of Rhodesia, up to June 30, 1914, showed a balance of cash on hand of £60,132, of which £56,964 was realized on concentrates shipped during the last year, previous to June 30. The total developed footage in the mine now amounts to 12,841 ft. The concentration plant has been in continuous operation during the year, and a total of 2221 tons of concentrates containing 1046 tons of copper was produced.[2]

The Otavi Mines and Railway Co., German Southwest Africa, has had a successful year. The profits from mining operations and from working the railway for the government for the last 3 years has been as follows: 1912, £134,188; 1913, £191,015; 1914, £208,310. The company's mining operations are conducted in the main at the Tsumeb deposit, where at first the ore was obtained by open-cut, but where for some time past it has been secured by ordinary mining operations of shaft and driving. The mine has now been opened to the fifth level. At this level development work has proved the ore-bodies to be considerably more extensive than at the fourth level and the grade in no way inferior in quality to that in the higher levels. The main shaft has been put down to the sixth level, and there commencement of driving has been started. Exploring below the fifth level by two bore holes and a winze has ascertained continuity of ore in depth with lead and copper contents. The shaft is to be continued down to the seventh level. Erection of plant for concentration of ore, also screening and picking, has been going on, and such plant will come into operation shortly. The procedure of

[1] Figures for the first quarter only.
[2] *So. Afr. Min. Jour.*, Jan. 16, 1915.

the company is to effect shipments of the rich ore, also locally concentrate and smelt low-grade material.

The output of the Cape Copper Co. during the past year has decreased about 800 tons, owing to a rearrangement of the smelting plants and to a lower price obtained for copper. The net profits for the year are given as £17,244. In the Nababeep mine the ore reserves have been increased from 150,000 to 160,000 tons through the discovery in the western part of the mine of a new body of ore of somewhat richer copper content than the average run of the mine. The O'okiep mine, which is very low in ore reserves, has continued to produce with no apparent diminution of reserves. The Rakha Hills mines will add considerably to the company's output of copper, although some time must elapse before the plant will be ready to treat the large tonnage already developed. The results of the development work during the year were satisfactory, for not only was there distinct evidence of improvement of grade in depth at the No. 1 shaft, which was then about 900 ft. deep, but also lateral extension of the lodes was shown, with wider ore-bodies, at the No. 4 shaft, 3500 ft. distant from the No. 1. The development during the year had increased the ore reserves by 68,542 tons, having practically the same average assay value as the ore previously proved. The ore in reserve at both shafts, fully or partially developed, amounted at the end of August to 307,747 short tons, the gross copper contents of which worked out at over 12,000 short tons. All effort was now directed to the completion of the plant, which would enable them to begin production.

Asia Minor.—The Ottoman government is reported to have decided to sell the copper mines of Arghana in Asia Minor, which have up to the present been exploited by the Ministry of Public Works. Many financial groups have desired to obtain the concession; the Deutsche Orient bank has offered an advance of a million Turkish pounds, and it is reported that an English firm has proffered £1,600,000. The mines are situated in the Province of Diarbekir. The aggregate volume of the cupriferous deposits is estimated to be 1,200,000 tons, principally pyrites, averaging 15.65 per cent. of copper.[1]

Australasia.[2]—The production of copper in Australasia during 1914 was 37,592 metric tons,[3] as compared with 47,325 tons in 1913. The decrease in output is due to the effects of the European war on the copper industry the world over, causing a failure of the market and a reduction in the price.

For the first 6 month of the year, the price of electrolytic copper was well over £60 per ton, and under normal conditions there was every

[1] *Min. Jour.*, July 25, 1914.
[2] Abstract of review by W. P. Geary, *Eng. Min. Jour.*, Jan. 23, 1915.
[3] As reported by Henry R. Merton & Co.

reason to expect that the price would maintain a fairly high average, which would stimulate copper mining to a great extent in Australia.

Queensland produced 18,436 tons this year, the chief producers being the Mt. Morgan and the Cloncurry fields. The Chillagoe, Ltd., closed down its smelteries early in the year, owing to the high cost of fuel and the slow progress made with the construction of the railway at Mt. Mulligan, whence the Chillagoe company intended drawing its supply of fuel. The Mt. Elliott, Ltd., has also closed its smelteries, being only engaged in development work at present, while the Great Fitzroy mines have been closed for the greater part of the year.

The Mammoth copper mine in north Queensland, which promised so well in the early part of the year, has had to suspend smelting operations through the effects of the war.

Western Australia should account for about 750 to 1000 tons, the principal copper fields being the West Pilbarra and Phillips River. In the latter district, the state government has recently erected smelteries for producing blister copper.

The properties in New Guiana are still in the prospecting stage and their production does not seriously affect the output of Australia.

New South Wales.[1]—The value of the output of the copper mines of the state for the year is estimated at £274,671. This is £324,062 in value less than in the preceding year, and is the lowest value recorded for the production since 1898. One of the chief causes of the lessened output for the period under review was the closing down of the smelters at the Great Cobar mine on April 9, 1914, and to date operations have not been resumed. Other important mines, such as Cadia, Lloyd (Burraga), Grafton (Cangai), and those in the Dandaloo and Nymagee divisions suspended work on the outbreak of the war, and the production from these sources was affected accordingly. The value of the output from the Cobar district, which is the principal center of the copper mining industry, was £116,460, as compared with £391,914 for the year 1913, or a decrease of £275,454. At the works of the Electrolytic Refining & Smelting Co. of Australia, Ltd., Port Kembla, the production of metals during the year included 17,570 tons of electrolytic copper, which was chiefly obtained by the treatment of mattes and ores imported from Queensland and other states, only a small proportion being won from the products of the mines of New South Wales. The value of copper produced in the state to the end of 1914 is estimated at £12,657,506.

South Australia.—The copper production of South Australia in 1914 amounted to 6881 tons, as compared with 7161 tons in 1913. The most important mines in South Australia are those of the Wallaroo and

[1] *Austral. Min. Stand.*, Apr. 8, 1915.

lining & Smelting Co.
o the report of the general
r the year 1914, satisfac-
ess attended operations
ar broke out in August.
of exploration and de-
outlined in the annual
1912 and 1913 as neces-
he maintenance of the
put of ore was vigorously
roughout 1915, except
s following the outbreak
when some difficulty was
ıcing the company's oper-
emporary arrangements
outh Australian govern-
10 per cent. retention of
not fully meet the case
the drop in the price of
was found necessary to
per cent. deduction from
wages on Oct. 1.
llaroo mines during 1914
6,365 metric tons of ore
5221 tons of fine copper,
ge of 9.26 per cent. The
in 1913 was greater but
content of the ore was
at the copper output in
7 tons greater than that of
us year. The Moonta
wed an increase in ore
over the 6421 tons in
37 tons net in 1914. The
acted from these ores for
s amounted to 789 and
espectively, and the aver-
tages of copper for the
ars were 12.29 and 15.37.
tation plant of the Moonta
luced 738 tons of copper
ing 942 tons of copper

PRODUCTION OF COPPER IN AUSTRALASIA
(In tons of 2240 lb.)

Year.	New South Wales.				Queensland.		South Australia.		Tasmania.				Western Australia.			
	Ingots, Matte and Regulus.		Ore.		Copper, Tons.	Value.	Copper, Tons. (a)	Value.	Blister copper.		Copper ore.		Copper ore, Tons.	Copper Tons. (b)	Combined Value.	
	Tons.	Value.	Tons.	Value.					Tons.	Value.	Tons.	Value.				
1907	8,963	£716,759	1,135	£11,015	12,756	£1,028,179	7,931	£690,000	8,247	£832,691	788	£36,975	3,727	1,602	£203,376	
1908	8,679	496,564	392	6,248	14,961	893,535	5,628	338,000	8,833	603,063	1,185	6,588	2,503	479	57,091	
1909	6,857	423,642	109	1,095	14,494	853,196	5,697	334,584	8,638	586,419	1,588	21,619	6,959	833	104,644	
1910	8,435	450,491	4,455	35,766	16,387	932,489	5,102	306,120	8,193	553,822	671	13,150	6,309	1,281	95,928	
1911	10,618	578,198	1,482	11,904	20,384	1,151,351	5,922	332,500	6,022	385,797	2,286	22,852	9,825	829	78,364	
1912	8,990	560,025	2,044	19,766	23,120	1,608,280	6,295	461,500	5,136	430,965	1,392	9,479	13,607	1,703	120,158	
1913	9,153	595,526	308	2,907	23,655	1,660,178	7,161	488,986	4,569	364,332	1,967	10,932	(c)4,339	(c) 82	145,513	
1914	3,500	274,671	.....	.....	18,436	.....	6,881	417,487	7,909	477,361	3,288	18,680	.....	.....	.....	

(a) Small amounts of copper ore and sulphate not included here. (b) Ingots and matte. (c) Exports.

ore, or 78.36 per cent. This is a better showing than was made in 1913, and the increased output is ascribed to improvements that have been made in the slime treatment. The Wallaroo smelting works treated 56,466 tons of ore, matte, and precipitate from the Wallaroo and Moonta mines, and obtained 7022 tons of refined copper, 2702 oz. gold, and 2936 oz. silver. The quantity of bluestone made was 3¾ tons.

The cost of producing the refined copper and placing it f.o.b. ocean steamer, including mining, smelting, repairs, maintenance, shipping charges, and office expense, amounted to £51 18s. 3 d. per ton, as compared with £56 15s. 10d. for 1913. The principal saving in production cost during the past year was due to cheaper mining and smelting.

The vein stuff raised during the year from the Wallaroo mine was 126,290 tons having an assay value of 3.967 per cent. copper. The concentrating plant at Devon treated 56,845 tons of vein material from underground and 67,368 tons of re-treatment material from the waste dump. The recovery of copper for the past 3 years was 80.8, 88.1, and 94.0 per cent., respectively. The Moonta mines hoisted 30,708 tons of vein stuff having a copper content of 3.761 per cent.

Tasmania.—The Mount Lyell company is the largest producer in Tasmania. The estimated production for 1914 was 7500 tons of copper, of which the Mt. Lyell company produced 7168 tons, and the remainder is due to the only other copper mine of any consequence, Murray's Reward.

The total tonnage of ore and metal-bearing fluxes mined by the Mt. Lyell M. & R. Co. during the half year ended September 30 was 171,250 tons, as compared with 169,857 tons for the previous half year; this included 105,283 tons from the Mt. Lyell and 65,819 tons from the North Mt. Lyell mines. No calculations of reserves have been made this half year, but they are estimated at 1,991,789 tons at the Mt. Lyell, assaying 0.531 per cent. copper, 1.96 oz. silver, and 0.0275 oz. gold, and 959,832 tons at the North mine, assaying 6 per cent. copper, 1.33 oz. silver, and 0.005 oz. gold. The output for the half year was 3864 tons copper, as compared with 3391 tons in the previous term, 5280 oz. gold, against 3391 oz., and 230,592 oz. silver, against 231,740 oz., and the cost of producing the blister was £1 1s. 2.53d., against £1 0s. 4.01d. per ton, an increase of 10.52d. The net profit was £29,317, as compared with £61,954 in the previous half year. At the end of the previous half year 821 tons of copper remained unsold, and was taken into account at £60 per ton. This was sold at an average of £63 13s. 11d. Of the 3864 tons of refined copper since produced, 1547 tons was sold (1400 tons after the declaration of war) at an average of £52 18s., leaving 2317 tons unsold September 30, which is taken into account at £50 per ton. Since

the accounts were made up further sales have been made, amounting to 750 tons, the average price realized being £52.

At the North Lyell mine ore production continues on normal satisfactory lines, with the output keeping at between 10,000 and 11,000 tons a month, and the average grade right up to 6 per cent. At the 1100-ft. level, No. 41 stope ore-body is still yielding an appreciable tonnage of high-grade ore. They are pushing ahead as fast as possible with the sinking of No. 2 engine winze, but the extremely hard nature of the country is against anything like good progress. The depth to date is about 80 ft., progress being at the rate of about 4 ft. a week. At the 1000-ft. level very good grade ore continues to be won from No. 40 stope on its northerly ground floor extension into the Comstock area, while the stopes at the 925-, 850-, and 700-ft. levels are all maintaining excellent value.

At the Mount Lyell mine they are making fair progress with the deepening of the main shaft and a depth of about 55 ft. below No. 8 level has been reached. The extraction of pyrite for smelting requirements is going on at the rate of between 16,000 and 17,000 tons a month, most of this coming from underground.

Austria.—Copper production of Austria in 1913 was as follows, according to a consular report from Vienna: Of 32 works for producing copper ore, 10 mills, with 26 overseers and 753 workmen, were in operation in Austria in 1913. About 163,533 quintals (quintal = 100 kg. or 220.46 lb.) of copper ore, valued at 1,542,296 crowns ($313,086), was produced. In this output, which shows a decrease of 5.76 per cent. compared with the preceding year, the government mines furnished 2.36 per cent. and the mines under private ownership, 97.64 per cent. The mills produced 36,845 quintals of metallic copper, valued at 5,986,409 crowns ($1,215,241). Copper works controlled by the mining authorities produced, besides copper, speiss and copper regulus, 8966 quintals of copper vitriol, valued at 514,970 crowns ($109,806). The entire production of the province of Tyrol, 95.36 per cent., is controlled by the government, and the full yield of the province of Salzburg, 4.64 per cent., by private works.

Bolivia.—Corocoro is the most important copper district of Bolivia. It is now connected with the coast of the new Arica-La Paz railroad, and is 339 km. from the port of Arica. During 1914 the production of copper in Bolivia was 2743 metric tons, as compared with 3,658 tons in 1913. The decrease was due to the European war as the *barrilla*, a high-grade ore containing about 84 per cent. copper and obtained from the native copper deposits, has formerly been shipped to Europe, but since the outbreak of hostilities shipments have ceased.

The Arica railway has brought about a considerable development in

Corocoro during the last year. Before this railroad was built, the *barrilla* was sent to the coast through the port of Mollendo in Peru; the journey was long, required various transfers at Lake Titicaca and at the Rio Desaguadero. To-day the *barrilla* is loaded in railroad cars in Corocoro and goes directly to the docks at Arica, with the great advantage of no breaks in the sacks or other important losses. Another of the great advantages of the railroad to Arica is that to-day the copper sulphides that occur abundantly in the veins can be exported without concentration.

The district contains many copper veins; for more than 100 years only the native copper ore has been worked. The sulphide veins were not touched because it was impossible to export the crude sulphide ore by way of Mollendo, on account of the difficulties of transport. At times there were not enough llamas and at other times the Rio Desaguadero contained very little water and, of course, the freighting was expensive.

The native-copper veins also contain ruby copper ore (Cu_2O); the *yanabarras* veins, as they are called in Corocoro, are accompanied by green sulphates. The *yanabarras* are the black sulphides without iron that correspond to chalcocite (Cu_2S) and are found in an arsenical gangue. The sulphide ores lend themselves to concentration; but this company has limited its efforts to the exportation of *yanabarras* and sulphates carrying 18 per cent. or more. There are veins of *yanabarras* that have a width of 9 m. with an average grade of 5 per cent. These are not yet touched, as the company hopes first to study a method of concentration. The Cia. Corocoro of Bolivia was exporting in November at the rate of 1500 tons monthly of ore having a grade of 18 per cent. The green sulphates of copper have little depth and at a few meters one encounters the unoxidized *yanabarras*.[1]

Canada.—The copper contained in matte, blister copper, etc., produced in Canadian smelters, together with the estimated recoveries or amounts paid for in ores exported, amounted in 1914 to 75,738,386 lb. which, at the average New York value of refined copper, would be worth $10,301,935. Compared with the production in 1913, which was 76,976,925 lb., valued at $11,753,606, there was a falling off of only 1,238,539 lb., or 1.6 per cent., but, owing to the lower price, a much larger percentage decrease in total value. The production by districts was as follows:

CANADIAN COPPER PRODUCTION
(In pounds)

	(*a*) 1911.	(*a*) 1912.	(*b*) 1913.	(*b*) 1914.
Quebec	2,436,190	3,282,210	3,455,887	4,201,497
Ontario	17,932,263	22,250,601	25,884,836	28,948,211
British Columbia	35,279,558	50,526,656	45,791,579	41,221,628
Yukon	.....	1,772,660	1,843,530	.....
Total	55,648,011	77,832,127	76,975,832	75,738,386

(*a*) Min. Prod. of Canada for 1912, Ottawa, 1913. (*b*) Min. Prod. of Canada, Preliminary Report for 1914, Ottawa, 1915.

[1] Corocoro Copper District, Bolivia, *Eng. Min. Jour.*, Jan. 23, 1915.

The production in Quebec from pyritic ores was 4,201,497 lb., as compared with 3,455,887 lb. in 1913. The actual copper content of the ores shipped was nearly 50 per cent. in excess of these figures, but only about two-thirds of the copper is reported as paid for.

The Ontario production is derived chiefly from the nickel-copper ores of the Sudbury district and of the Alexo mine, although there is a small amount of copper contained in the silver ores shipped from Cobalt, some of which is paid for. There was also a small shipment from the Dane mine on the T. & N. O. railway.

The production in 1914 is reported as 28,948,211 lb., an increase of 3,062,282 lb. over the 1913 output, which was 25,885,929 lb. The Mond Nickel Co. contributed a much larger percentage of the total production during 1914 than in 1913, and as this company's ores are higher in copper than those being worked by the Canadian Copper Co., we have the perhaps somewhat unexpected result of a decrease in nickel production accompanied by an increase in copper production from these Sudbury district ores.

Nickel contents of Bessemer matte are estimated at 22,000 tons, worth $4,900,000, and copper contents 14,250 tons, worth $2,000,000. The Canadian Copper Co. some time ago believed its great Creighton mine was approaching the point of exhaustion. Consequently, the huge but lower grade deposit known as Frood, or No. 3, mine was opened up, a town was built by the company for its workmen, and operations on a large scale begun. The diamond drills which meantime had been exploring the Creighton, reported the existence of large reserves previously unknown. Work was stopped at the Frood, and again the company is drawing its main supply from the Creighton mine. The Alexo mine in Dundonald township, which had been shipping ore to the Mond smeltery, discontinued consignments when war was declared, but has since resumed them.

The British Columbia production was 41,221,628 lb., as against 45,791,579 lb. in 1913, a falling off of 4,569,951 lb. The Greenwood smelter closed down in August and the Grand Forks smelter restricted its operations very severely on the outbreak of war, but started up several furnaces again before the close of the year. The blowing in of the smelter at Anyox, treating the Hidden Creek and other coast ores, and the continuance of large shipments from the Britannia mine made the coast production slightly greater than that of the southern interior smelters and, with an increased production at Trail, almost compensated for the falling off in the Boundary district.

The British Columbia Copper Co. blew out its plant in August, and also shut down its mine. At its Mother Lode mine in the Deadwood

camp, about 178,000 tons of ore was mined, at the low figure of 85.48 cts. on board cars. A slight increase in cost here is due to the necessity of mining more ore by stoping instead of by glory-hole methods. Up to Aug. 20 the company had smelted 295,000 tons, of which 191,000 was company ore, the balance being custom ore. Something over 4,000,000 lb. of copper was produced, 14,442 oz. of gold and 63,501 oz. of silver. The company is operating a group of claims with about 25 men at Copper Mountain, 12 miles south of Princeton, in the Similkameen district. The result of the work here indicates a reasonably assured reserve of 5,000,000 tons and more, with excellent chances for this to be increased. The Granby closed down its Phoenix plant somewhat earlier than did the British Columbia, but resumed operations again on a reduced scale; it is rumored that a gradual increase to full capacity is planned. The Consolidated Mining & Smelting Co., at Trail, resumed the acceptance of shipments in October, making partial payments for the contents of custom ore with arrangements for later complete payment.

The copper production of the coastal district shows a remarkable increase for the year 1914 over that of previous years, as shown in the following table covering the last 5 years.

COPPER PRODUCTION OF THE COASTAL DISTRICT[1]

	Lower Coast, Lb.	Portland Canal Skeena, Queen Charlotte, etc., Lb.	Total, Lb.
For 1910	3,078,090	.....	3,078,090
For 1911	10,998,721	19,151	11,017,872
For 1912	15,429,778	88,403	15,518,181
For 1913	14,443,793	3,174	14,446,967
For 1914	13,070,245	11,129,376	24,199,621
Totals	57,020,627	11,240,104	68,260,731

Of the total production of copper in the Coastal districts during the last 5 years, 36 per cent. was produced in 1914, in which year the output was more than 50 per cent. larger than in any other year since a beginning was made to produce copper from mines in this district. It should be noted that nearly all of the 1914 production was made at two mines—the Britannia, near Vancouver, and the Hidden Creek, on Observatory inlet. Neither of these mines, however, was worked to capacity last year, war conditions having prevented, so that when normal conditions shall be restored it will not be unreasonable to expect an output from them of 40,000,000 to 45,000,000 lb. of copper a year, without including the output of several much smaller mines that will probably also be producers in the near future.

The total quantity of copper produced in the province in all years, as shown in the official records of the British Columbia Department of

[1] *Can. Min. Jour.*, May 1, 1915.

Mines, was 503,737,902 lb. Of that total approximately 65,251,000 lb. was from what is officially known as the Coast district, and 1,721,000 lb. from mining divisions included, officially, in Cassiar district. If there be added to the total of the whole province the production of 1913 and 1914, say 91,460,000 lb., a grand total for all years of, in round figures, 595,198,000 lb. will be obtained. It is noteworthy that more than 50 per cent. of that total was the production of 7 years, 1908–1914.

The Pueblo mine was again the principal copper producer in the Yukon with an output only slightly less than that in 1913.

The New York price of electrolytic copper fell off from 14.7 cts. in February to 12.7 cts. during the last week of July. Quotations ceased on the declaration of war but were resumed in November at a little over 11 cts., increasing to 13.2 cts. in December. The average monthly price for the year was 13.602 cts., as against 15.269 cts. in 1913, and was with the exception of 1912 and 1913 the highest average since 1907.

There was a large falling off in the imports of copper of all kinds in 1914. The total imports were valued at $4,256,901 and included crude and manufactured copper, 28,280,812 lb., valued at $3,983,322, copper sulphate, 1,143,039 lb., valued at $53,802; and other manufactures of copper, valued at $219,777. The total imports in 1913 were valued at $7,415,008 and included crude and manufactured copper, 41,011,961 lb., valued at $6,935,822; copper sulphate 2,037,714 lb., valued at $107,960 and other manufacturers, valued at $371,226.

The exports of copper were: copper fine in ore, matte, etc., 68,830,059 lb., valued at $7,130,778; and copper black or coarse, etc., 6,581,564 lb. valued at $908,201; a total of 75,411,623 lb., valued at $8,038,979.

Chile.—The copper production of Chile during 1914 was slightly in excess of that of the previous year, the figures for the 2 years being 40,876 and 39,434 metric tons, respectively. Of last year's production the United States received 23,814,659 lb. of blister copper and 29,056,280 lb. in the form of ores. England and France received 37,244,960 lb. during the year, making the total of exported copper from Chile 90,115,899 lb. in 1914, as compared with 86,936,945 lb. in 1913. The production for the last 2 years as shown by the exports to the United States and Europe is shown in the following table:

COPPER PRODUCTION OF CHILE[1]
(In pounds)

	1913.	1914.
Blister copper to the United States	18,315,000	23,814,659
Copper in ore to the United States	24,911,465	29,056,280
Copper to England and France	43,460,480	37,024,960
Sundries	250,000	220,000
Total lb.	86,936,945	90,115,899
Total metric tons	39,434	40,876

[1] *Eng. Min. Jour.*, Revised Statistics, April, 1915.

At the Chuquicamata and Braden copper mines work was not abated on account of the war or the financial stress arising therefrom. Most of the smaller copper companies curtailed operations after August and some stopped completely. Exceptions to these were the Catemou, Naltagua, Chañaral, and the Copiapo companies and the Central Chile Copper Co., at Panulcillo, where important improvements were made, outlying properties optioned and a new power plant erected; in the north, at Collahuasi, the Poderosa and the Société Francaise des Mines de Cuivre mined their high-grade ores; the French company erected a small experimental plant to concentrate the low-grade siliceous ore now on the dumps. The Braden Exploration Co. explored its Potrerillos group of copper claims, about 90 miles back from Chañaral, and also made preliminary examinations of two properties in the vicinity of Santiago.

The enterprise of the Chile Copper Co., at Chuquicamata, was prosecuted vigorously in 1914, between 2000 and 3000 Chileans being employed on the work besides 200 or 300 Americans and Europeans. The prostration of the nitrate industry, owing to the European war, threw many laborers out of employment and furnished the Chuquicamata mines with an abundant supply of labor, enabling construction work to go forward with such expedition that the operating officials at the end of 1914 estimated that the plant would be ready for operation about Mar. 31, 1915. The equipment for the power station at the port of Tocopilla and for the electric substation at the mill was made in Germany, and when the war broke out a large part of this equipment was on board more than a dozen English and German steamships afloat in the Atlantic and Pacific Oceans, and part of it was still in Europe; fortunately, however, neutral ships were obtained and all of this material was gotten out of these steamships and out of Germany, and most of it is delivered. All of the equipment for the railway, the transmission line and the mine and some of the mill equipment was made in the United States and the installation of same was nearly completed. Officials of the company state that Chuquicamata is now the largest known deposit of copper in the world, and expect before long that it will be the largest and cheapest producer of copper in the world. The development of the mine by drills was continued in 1914 and the tonnage developed now exceeds 300 million; the exact amount reported by the company's engineers on Dec. 6, 1914, was 297 million tons, averaging over 2 per cent. copper.

The Braden Copper Co. continued its operations, increasing its developed tonnage and improving its metallurgical treatment. At the end of December, 1913, Consulting Engineer Pope Yeatman reported 78,000,000 tons of 2.5 per cent. copper ore, classified as developed, probable, and possible; the work of 1914 materially increased this tonnage.

The company produced at the rate of about 2,400,000 lb. of copper per month. One of the features of the metallurgical improvement was the installation of the preliminary nodulizing kiln, of which three were shipped; the first kiln did good work and led the company to anticipate satisfactory results in preparing the flotation concentrates for treatment in the blast furnaces.

The Gatico Copper Co. has for many years past steadily increased its production until at present it furnishes about 6 per cent. of the total output of Chile. In 1914 the production of this company was 2,414,506 kg. of converter bars, containing 98.5 to 99.5 per cent. copper.

China (By T. T. Read).—The domestic production of copper in China, chiefly from Yunnan and Kweichow provinces, is considerable, as is evidenced by a recent report from Wuchang that an order for 10,000,000 lb. for carriage purposes had been placed. All the mining and smelting is in the hands of natives, and no authentic records are kept. A company called the Ching Hua Mining Co. has recently been formed to develop a copper mine in the Nanchang district of Hupeh. Nothing has been heard recently of the smelting plant erected near Lanchow in Kansu, nor of the mines at Chang-pai-ling, in Kiangsi. At Pai-Shui-ho in Ssuchuan, a Chinese company is at work. The chief production from Ssuchuan comes from the government mines at Hui-li-chou, worked by native methods.

Copper mining also shows considerable development in Korea. The most important area is that comprised in the Kapsan concession, about 60 miles from the port of Songchin, on the east coast in northeastern Korea. The concession embraces about 4000 sq. miles, and has been under development since 1909. Proposals for the erection of a smelting plant of a capacity of 100 tons of ore per day were under consideration before the outbreak of the war. The mine was worked by the Koreans on a small scale for many years. There is small but increasing export of iron ore to Japan, which last year amounted to nearly 150,000 tons. It is understood that the Mitsu Bishi Copper Co. is considering the erection of smelters in Korea itself.

Cuba.—During 1914 Cuba exported to the United States ore and matte which contained 18,659,788 lb. of copper. This production comes chiefly from the El Cobre mines, a short distance west of Santiago. From 1839 to 1860 this property produced 788,880 tons of high-grade ore valued at $30,000,000, under the management of an English company. Since then the mine has been flooded and entirely abandoned, until after the Spanish-American war an American company obtained possession. Pumping operations for unwatering the mine were at once started on a very large scale, and a railway to the port of Santiago was built. The

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workings have not yet been pumped dry down to their old depth, and meanwhile mining is restricted to the poorer ores left by the old owners as unpayable. These average from 3.50 to 4 per cent. Cu. The output is concentrated by the Minerals Separation, Limited, flotation process, which is stated to give excellent results. The production, totalling about 50,000 tons concentrates and rich ores, is shipped for further treatment to the U. S. A. Whether the richness of the El Cobre lode will continue in depth remains, of course, to be seen. The El Cobre ores mainly consist of copper pyrites and copper glance.[1]

Germany.—As a result of the policy adopted by England with respect to the importation of copper or copper-bearing ores into Germany, that country has been cut off from every outside source of supply of copper and a very interesting condition has arisen. The following is a German view of the copper situation expressed in a report of the American Association of Commerce and Trade in Berlin, Dec. 19, 1914.[2]

It has been frequently said that the interruption of the copper import into Germany is a serious menace to her industries. Notwithstanding the fact that Germany produces only 2.4 per cent. of the world's copper production, which has a volume of 1,000,000 tons per year, no conclusion should be formed upon the resources of copper for Germany. In the first instance, with the interruption of the import the exports also ceased, and, therefore, all the copper formerly used for exports in manufactured form is available. Furthermore, it is almost an impossibility to prevent the importation of copper entirely.

The following industries have the greatest interest in the pending copper question; manufacturers of ammunition, vessels of all sorts, apparatus for breweries and distilleries, plates for copper printing, manufacturers of bronze and brass ware, electrical industries, parts for the chemical industry, etc. A distinction should be made as to the uses of copper for these various industries, referring to refined copper of the best quality and ordinary copper as is utilized in many instances for various purposes.

In order to insure the supply for the army and navy, the authorities have taken the supervision into their hands in regard to the trade in refined copper. There are large quantities on hand of ordinary copper in the form of scrap copper, sufficient for the yearly demand of 8 lb. per capita, which is the same amount that is used, as per statistics in times of peace. The German copper coins alone represent a weight of approximately 8000 tons; many copper products becoming unserviceable are

[1] The Occurrence of Copper and the Mines at El Cobre, Cuba. E. Neuman, *Metall u. Erz*, pp. 221-6, 1913.

[2] *Eng. Min. Jour.*, Jan. 30, 1915.

ing remelted and the copper used over again. It was these reserves at caused the failure of the copper corner in 1889.

Germany can be considered a vast copper mine from the fact that has been imported in enormous quantities and retained in the country many forms of manufactured goods.

According to official data, the import of copper into Germany in 1913 nounted to 220,892 tons and the German copper production to 40,278 ns in the same year. The yearly copper import into Germany repre- nts a quarter of the entire world's production and within the last 10 ars nearly 2,000,000 tons has been imported.

In view of these facts it is not surprising that Germany, after four onths of war, is in a position not only to satisfy all demands of her my and navy, but largely those of her industries.

The German production of electrolytic and blister copper has mul- plied in comparison with former years, and is steadily growing, even ring the present war. Existing plants for the production of refined d blister copper are being enlarged, as large quantities of scrap copper, ings, residues containing copper, are being delivered, attracted by good ices, material which in time of peace was largely sent to Belgium, ngland, and France. On the other hand, copper is being replaced herever possible by other suitable material, as for instance, copper- vered material is now used for many purposes, where formerly pure pper was used.

A statement issued by the German Press Bureau at the end of ovember gives the production of copper from domestic ores at 45,000 etric tons, and states that the mines at Mansfeld, Eisleben, and Hett- adt are being worked day and night. These figures do not correspond ith what is known of German domestic production. The output from mestic ores and intermediate products was estimated last year at 5,000 metric tons. Indeed, the total production, including all im- rted raw material, is estimated at 41,000 metric tons for last year. nported pyrites would furnish the source of the great bulk of the pper thus recovered, and as practically the whole of it is derived from pain, Portugal, Norway, and France, it is difficult to see how any ore cept that already in stock can be available.[1]

Japan (By J. Kojima).—The estimated production of copper in Japan r 1914 is approximately 77,000 short tons,[2] which is about 5 per cent. reater than the output of the previous year. The increase would have een much greater had the European war not interfered and caused a arked curtailment during the latter part of the year. During the last

[1] *Min. Jour.*, Dec. 19, 1914.
[2] Advance statistics, Bureau of Mines, Japan.

few years the copper industry of Japan has made very remarkable advances and under favorable conditions for the coming year the production should go over 80,000 tons. The ore reserves are steadily increasing in the well-developed mines, and virgin territory has been carefully prospected with satisfactory results. Modern equipment is rapidly replacing the older machinery of the mines and reduction works, which is making possible the mining of low-grade ores long ago abandoned as worthless.

The following table gives the production of the principal mines for the last 4 years:[1]

COPPER PRODUCTION OF PRINCIPAL JAPANESE MINES
(In tons of 2000 lb.)

	1911.	1912.	1913.	1914.
Ashio	8,483	10,530	9,335	10,631
Kosaka	6,606	8,867	6,660	7,530
Hidachi	6,243	8,704	9,835	10,132
Besshi	7,573	8,537	7,523	7,446
Osarusawa	2,172	2,385	2,062	2,087
Ikuno	1,654	1,884	1,801	1,998
Furokura	2,014	1,719	.....	.....
Ogoya	1,246	1,540	1,441	1,482
Arukawa	1,410	1,413	1,056	919
Kamaishi	.....	.....	1,152	1,167
Ani	.....	.....	1,137	1,373
Other mines	20,252	23,299	9,749	10,691
Total	57,653	66,878	51,751	55,645

As shown by the production figures, the leading mines are the Ashio, Hidachi, Kosaka, and Besshi, and the owners of these also have smelters and concentrating plants.

The Ashio mines and smelter are owned by Furukawa & Co. The ore occurs in innumerable veinlets that intersect each other, and consists of the copper minerals, chalcopyrite and bornite, with various gangue minerals.

The mines are provided with 10 vertical shafts, measuring 6845 ft. in aggregate length, and have drifts that total more than 130 miles in length. The average yearly development work amounts to about 150,000 ft. Mining is carried on with up-to-date equipment, water power being used to drive air compressors and electric generators that supply light and power for hoisting and underground purposes. Four compressors each with a capacity of 1740 cu. ft. per minute supply the air for running the drills, etc.

The smelter is provided with three blast furnaces, three converters, seven pot roasters, two McDougall furnaces with power-blowing engine and turbo-blower, and is fed principally with concentrates that average

[1] Figures for 1913 and 1914, *Eng. Min. Jour.*, 99, No. 19.

11 to 12 per cent. copper. In 1914 the yield of copper was 23,827,030 lb. copper, containing 321,708 oz. silver, and a small amount of gold.

During 1914 railway connection was made from the large cities to the mines through the steep canyon of Watarase River, and in the fall it was extended to the smelter plant. More than a dozen aerial trams measuring 26 miles in total length are used for the transportation of waste, slag, limestone, timbers, etc.

The second largest producer of copper is the Hidachi group, owned by the Kuhara Mining Co. The ore consists of cupriferous pyrite which occurs in lenticular masses in Paleozoic clay slate and schistose rocks. The copper contents of the ore varies from 2 to 5 per cent., and the ore is sent to the smelter mostly without concentration.

The smeltery has 27 pot roasters, 2 reverberatory furnaces, 8 open-top blast furnaces, 4 converter stands, 5 Root's blowers, and 4 turbo-blowers. The converters are of the barrel type, having a diameter of 78 in. and a length of 96 ft. The output of the plant in 1914 was 22,708,-580 lb. of copper, of which 60 per cent. represents the copper content of company ores, and the rest was custom ore. Siliceous ores from the outside are welcomed, as silica is needed to flux the company's ores. The smelter is unique in having the largest smokestack in the world, being 511 ft. high and having a diameter of 50 ft. at the base.

The Kosaka mines and smelter are owned by Fujita & Co., of Kosaka, Akita, and rank third in copper production. The ore occurs in massive form and consists of a complex of the sulphides of the base metals, formed by metasomatic action along a contact zone. It averages 2.3 per cent. copper and carries values in gold and silver along with 2.4 per cent. lead and 12.7 per cent. zinc. Mining is carried on in open cut as at Bingham, Utah, more than a dozen terrace levels being worked at the same time. It is supposed that the richer parts of the ore-body have been mined out, and a somewhat leaner ore zone surrounding the older workings, and of great size is now furnishing the low-grade material from which the values are recovered by careful milling processes. The mills of the company have in course of construction a daily capacity of 3000 tons.

The Kosaka smelter receives the concentrates from the mill and treats in addition almost an equal amount of custom ore from other mines. The output of the smelter in 1914 was 16,854,560 lb. of copper, 963,898 oz. silver, and 10,878 oz. gold. The plant is provided with 6 pot roasters, 3 sets of briquetting presses, 7 jacket furnaces, 2 converter stands with hydraulic accumulators, 2 turbo-blowers, and 5 Root's blowers. An electrolytic process has been devised for the recovery of metallic zinc from the mixed sulphide ore and also from the slag, and is reported to be successful.

The Besshi mines and the Shisaka smelter are owned by the Sumitomo Copper Co., of Osaka, and hold fourth place in point of copper production in Japan. The Besshi copper deposit is a bedded vein occurring in crystalline schists of Paleozoic, or possibly of Archean age, and is traceable along the strike for 5000 to 6000 ft. It varies in thickness up to 30 ft. The ore is a massive cupriferous pyrite containing from 4 to 5 per cent. copper, and upon being smelted yields a product singularly free from other metals, so that it commands a high price and needs no electrolytic refining.

A new tunnel is being driven from a point about 1896 ft. below the third tunnel (the lowest drainage level at present) and is in 15,000 ft. and within 4000 ft. of the ore-body. A vertical shaft 20 ft. in diam. for hoisting purposes is being sunk from the third tunnel to meet the new one, and is within 300 ft. of the lower tunnel level.

The Shisaka smelter, located on the Island of Shisakajima, about 15 miles from the terminal of the railroad which transports the ore from the mines to the coast, was built in 1906 at a cost of 4,000,000 yen and is provided with modern equipment. There are in operation at the smelting plant seven 10-ton pot roasters and six blast furnaces. The matte from the blast furnaces, containing 17 to 18 per cent. copper, goes to 58 open stalls, and the roasted matted is smelted in circular crucible furnaces and finally finished in eight reverberatories. The product is blister copper averaging 99.8 per cent. copper tener. The coke needed in smelting is made in ovens at the plant, said to have a capacity of 250,000 tons of coal a year.

The output of the smelter in 1914 was 16,690,040 lb. of copper. On account of smoke troubles the production has had to be restricted during the season that the rice plants are in bloom, and to overcome this hindrance a sulphuric acid plant of 600,000 lb. yearly capacity is being built, and it is expected that the first quarter of the plant will be completed in the coming spring. Basic sulphide ore will be used for the acid manufacture, and fertilizer will be one of the by-products.

Electrolytic copper is produced at five different plants in Japan, namely: the Nikko works, the Kosaka, Hidachi, Mitsubishi, and the Osaka refineries. The monthly capacities of these plants are 2,700,000, 1,600,000, 2,400,000, 2,240,000, and 530,000 lb., respectively.

The export of copper from Japan during 1914 has diminished slightly from that of the previous year, probably owing to the fact that there is a growing demand within the home country for copper for manufacturing purposes. The following table shows the exports to Europe, Asia, and America during the last 10 years.

COPPER EXPORTS OF JAPAN
(In tons)

	Europe.	America.	China.	India.	Totals.
1905	2,813	.....	17,242	52	20,107
1906	23,997	3,628	5,757	82	33,464
1907	13,670	3,569	14,002	410	31,651
1908	25,000	5,515	2,220	2,766	35,501
1909	22,170	9,528	1,589	2,088	35,375
1910	21,116	8,846	957	4,218	35,137
1911	17,288	11,009	3,688	2,322	34,307
1912	23,351	6,917	7,317	805	38,390
1913	19,843	5,543	13,320	3,574	42,280
1914	19,642	5,207	13,577	3,274	41,700

Mexico (By W. G. Matteson).—The copper production of Mexico has steadily decreased since the series of civil revolutions was initiated, the output for 1914 totaling only 36,337 metric tons, as compared with 58,323 metric tons in 1913 and 73,617 metric tons in 1912. This reduction of 38 per cent. from the production of 1913, and of 50 per cent. from the record production of 1912, is an accurate barometer of the true state of the mining industry, which has progressed continually from bad to worse until it has reached the most chaotic condition in its history, owing to the disagreement and pernicious activities of the various revolutionary factions. Even the mining companies at Pachuca and El Oro which, owing to their centralized location with respect to Mexico City have usually been able to maintain operations in spite of many difficulties, were forced to suspend work during a considerable portion of the year.

Mexico's copper production for 1914 was largely due to activities within the states of Sonora and Lower California where, owing to isolation and proximity to the United States border, interference was not so pronounced.

Lower California.—Operations were maintained in the state throughout the year with practically little interruption, in consequence whereof Boleo registered a satisfactory production.

Sonora.—Although the Cananea Consolidated Copper Co., the largest copper-producing corporation in Mexico, has generally been able to maintain operations in spite of almost insurmountable difficulties, the company was forced to suspend work for some time owing to the destruction of railroad bridges, the subsequent cutting of transportation facilities with the United States, and the lack of responsible governmental authority, followed by numerous strikes on the part of the laborers who sought to take advantage of conditions. For a considerable period only sufficient Mexicans were employed to keep the mines unwatered, while dissenters started serious fires in the Veta Grande and Oversight properties. Differences were finally adjusted the latter part of

July, when the strikers were ordered to return to work or fight, the former alternative being unanimously adopted.

The Moctezuma Copper Co., at Nacozari, continued operations at normal capacity for the greater part of the year, making an admirable showing in the face of the rather unsatisfactory conditions, but in October even this corporation was compelled to curtail operations to 60 per cent. of capacity.

Mining operations show an increase of 500,000 tons of ore in reserve. The Pilares, the main hoisting shaft, was sunk to 1285 ft., and a little work there exposed a considerable tonnage of good average grade ore. The Esperanza and Guadaloupe shafts are down 1266 and 1000 ft., respectively.

The mill produced 120,655 tons of concentrate which, with some slime and other ore, was shipped to the Copper Queen smelter at Douglas. It contained 1006 oz. gold, 435,482 oz. silver, and 32,299,211 lb. copper.

Net earnings totaled $1,189,100, and $1,170,000 was paid in dividends.

The Nacozari Copper Co. was able to continue work on a reduced scale. During one period practically all of the American employees were forced to leave, owing to a promulgated statement of Gen. Carranza.

Cobre Verde, a new copper property 3 miles north of Santa Rosa, made several ore shipments to Douglas during the year. Leasers worked intermittently around Santa Rosa and also throughout the Cananea district. The Minneapolis Copper Co. continued operations on a small scale.

Zacatecas.—The Mazapil Copper Co. remained idle during the entire year. Owing to the activities of the various factions in Zacatecas, this rich company with valuable copper, silver, lead, zinc, and pyrite mines at Aranzazu, San Eligio, and Concepcion del Oro has been forced to suspend work indefinitely.

Puebla.—The Tezuitlan Copper Co., operating in the Tezuitlan district of Puebla, has closed its mines and smelter. The branch railroad to the property has been cut repeatedly.

Chihuahua.—The Corrigan-McKinney properties at Terrazas, Chihuahua, have been idle the greater portion of the year. Operators in the Concheño copper district have been able to work intermittently.

Future Outlook.—Mining activities in Mexico were greatly discouraged by the proclamation of August 20, 1914, issued by Vestusiano Carranza at first chief of the Constitutionalist army. This statement canceled all mining titles obtained during the Huerta administration and decreed that all proceedings relative to the acquisition of mining claims commenced during the Huerta régime to be null and void. Sixty days were granted in which applications for renewal of all procedure previously

taken could be made. The order further stipulated that all payments required by the mining laws of Mexico in connection with mining titles or mining claims must be made again to the present administration. All rights were forfeited by persons who did not comply with the above-mentioned rules before the expiration of the said 60 days, and mining land thereafter was considered as open to denouncement.

The re-payment of mining fees with the changing administrations is not a new form of extortion, having been applied in Sonora in 1913. In order to protect their properties, companies have generally paid double or triple taxes under protest.

The future of the mining industry can not be said to look particularly bright at the present writing. The last disagreement of Carranza, Villa, and Zapata, followed by renewed strife, the enforced operation of some properties for the purpose of providing bullion for the army leaders, the necessity of paying premiums on their own bullion desired to pay off their own employees, the continued issues of paper money in the armies against the silver and gold of the mining companies, and the absolute lack of protection against mob outrages, with no apparent end to the prevailing chaos, has caused the majority of operators and mining companies to despair of economical operation, with a subsequent closing of mines until peace is concluded and protection assured.

Peru.—The production of copper in Peru during 1914 shows a decrease, as compared with the output of the previous year. According to Henry R. Merton & Co., the figures for last year are 23,647 metric tons, as compared with 25,487 tons in 1913. The total amount of ore smelted is estimated at 130,000 tons. During the year the United States received from Peru 44,488,809 lb. of blister copper and 5,680,592 lb. of copper in ore that was treated here. England and France received during the same period 1,962,720 lb. of copper, the total exported to the three countries amounting to 52,132,121 lb., or 23,647 metric tons. The production based on the exports to these countries during the last 2 years is shown in the following table:[1]

COPPER PRODUCTION OF PERU

(In pounds)

	Peru—1913.	Peru—1914.
Blister copper to U. S.	42,667,436	44,488,809
Copper in ore to U. S.	10,089,592	5,680,592
Copper to England and France	3,180,800	1,742,720
Sundries, estimated	250,000	220,000
Totals, lb.	56,187,828	52,132,121
Totals, metric tons	25,487	23,647

The two largest operating companies producing copper are the Cerro de Pasco Mining Co. and the Backus & Johnson Co., and the bulk

[1] *Eng. Min. Jour.*, Revised Statistics, Apr., 1915.

of the output of the country comes from their mines and reduction works. These companies worked at full capacity until the outbreak of the war, when they curtailed their output about one-half. Many of the smaller companies closed down.

Cerro de Pasco in the last half was producing at the rate of about 2,500,000 lb. per month, whereas its properties now have a capacity of over 6,000,000 lb. The company's production in 1914 amounted to about 42,000,000 lb. The capacity of the Cerro de Pasco Co.'s smelter is about 1000 tons per day, which amount is supplied chiefly by the company's mines at Cerro de Pasco and Morococha, supplemented by ores purchased from La Docena and other small producers. The predominating minerals of Cerro de Pasco are argentiferous galena, chalcopyrite, panabase (a variety of tetrahedrite), and sphalerite, with a gangue of clay and quartz. The ores of La Docena are tetrahedrite and enargite with a siliceous gangue, carrying on the average 10.5 per cent. copper, 32 oz. silver, and 0.3 oz. gold per metric ton. The Backus & Johnson Co. in 1914 completed its campaign of improvements, but reduced its output. It now owns a hydro-electric plant of from 3000 to 4000 h.p.

Russia.—The copper production of Russia during 1914, according to Henry R. Merton & Co., was 31,938 metric tons, as compared with 34,316 tons in 1913.

The production of copper according to districts was as follows:

District.	1913		1914	
	Poods.	Tons.	Poods.	Tons.
Ural	997,279	16,085	1,026,723	16,560
Caucasus	619,398	9,990	517,452	8,346
Siberia	346,684	5,591	338,088	5,453
Chemical works and refineries	85,032	1,371	86,397	1,393
Total	2,048,393	33,037	1,968,660	31,752

The works of the Caucasus Copper Co. and the Kwarzchana works of the Siemens Copper Co. have been, since Nov. 4 (old style), in the hands of the enemy. The first ones were producing 18,000 to 28,800 lb. daily, the last one was in course of construction and expected to start operation at the beginning of 1915.[1]

The probable effect of the war on the copper industry of Russia is difficult to determine. It is subject to two influences: first, the great demand from the military point of view, and second, the serious inroads made on the supply of labor for the mines due to the calling of men to the colors. The state of war strikes the industry at a moment when it is in a very unpromising condition. In the past few years copper production of the country has grown surprisingly fast, and it was freely prophesied that

[1] *Eng. Min. Jour.*, Feb. 13, 1915.

the present year would see the end of the importation of foreign copper into the country and the beginning of the exportation of Russian copper abroad. But last year this growth was arrested. The reasons given might be held to be satisfactory, if all true, namely, that a number of companies had stopped production for the purpose of renewing and extending their plants. Unfortunately this view had to be taken, however, with a knowledge that the slackening in progress affected more than one important copper-producing district, and it seemed remarkable that the country's industry should have started marking time just at a period when industry generally in Russia was unprecedentedly good, and the demand consequently a large one and one to be taken advantage of, so that when the inevitable general trade depression should arrive the alterations, admittedly so much required, could be made. A fresh complication, as far as the Caucasus is concerned, has supervened through the military activity of the Turks who, it is reported, have got control of the largest Caucasian copper property, which it is said to be the intention of the Russians to promptly recover possession of, if for no other reason than the desire to deprive the Germans of this source of supply of an article of which they stand in such reported urgent need.[1]

Spain.—The copper output of Spain for the last 4 years is given in the following table:

COPPER OUTPUT OF SPAIN AND PORTUGAL
(Long tons)

	(a) 1911.	(a) 1912.	(a) 1913.	1914.
Rio Tinto	33,385	39,925	36,320	21,515
Tharsis	3,395	3,375	3,220	3,605
Mason & Barry	2,920	3,540	3,135	2,140
Sevilla	1,530	1,390	1,510	.....
Other mines	9,700	10,700	9,650	(b)1,941
Total	50,930	58,930	53,835	29,201

(a) Henry R. Merton & Co.
(b) All from the Cordoba Copper Co.

The total for 1914 as given in the table is incomplete. The estimate by Henry R. Merton & Co. gives the production for the year as 37,099 tons.

Rio Tinto[2]—The report for 1914 of this company, owning the leading copper-producing mine in Spain, shows that the properties were idle during the first few weeks owing to the strike. The men resumed work in February, and operations continued on the normal scale until the outbreak of the war. The loss of the German market for copper and pyrite necessitated a substantial curtailment of the output. The various de-

[1] *Min. Sci. Press*, Jan. 30, 1915.
[2] *Min. Mag.*, **12**, 239 (1915).

partments were kept going on the basis of 3 day's work per week, and even then the whole of the mineral raised could not be sold. Since the end of the year, the demand from other than enemy countries has improved, and work has been increased to the basis of 4 days per week. The removal of over-burden from the San Dionisio and South lodes has been continued. The underground development and the new deep-level approaches to the ore-bodies are reported to be well in hand. The sales of copper as metal and in ore were 21,515 tons, as compared with 36,320 tons in 1913, and the average price per ton was £59 9s., as compared with £68 5s. The divisible profit was £899,939, as compared with £1,673,372. Out of the profit £81,250 was paid on the 5 per cent. preference shares, and £656,250 on the ordinary shares, being at the rate of 35 per cent. A year ago the ordinary shareholders received £1,406,250, the dividend being at the rate of 75 per cent.

OUTPUT OF RIO TINTO MINES
(In long tons)

Year.	Pyrite for Shipment.	Ores for Local Treatment.	Total Mined.	Average Copper Contents, Per Cent.	Copper Produced at Mines.	Pyrite Sold.	Washed and Other Sulphur Ores Sold.
1903	688,919	1,229,619	1,918,538	2.390	21,565	667,748	118,174
1904	672,344	1,276,475	1,948,819	2.340	21,218	663,744	157,810
1905	627,336	1,202,768	1,830,104	2.363	19,530	660,724	308,184
1906	655,328	1,268,388	1,923,716	2.411	21,287	632,307	477,843
1907	641,858	1,265,090	1,906,948	2.417	21,251	607,944	619,814
1908	604,275	1,115,610	1,719,885	2.265	24,256	589,815	668,477
1909	604,799	1,184,188	1,788,987	2.349	24,364	600,946	569,604
1910	637,020	1,509,945	2,146,965	2.097	22,790	578,443	683,605
1911	649,215	1,536,390	2,185,605	2.144	21,880	662,259	841,964
1912	698,399	1,708,573	2,406,972	2.180	25,623	668,861	977,812
1913	652,168	1,207,403	1,859,571	2.190	21,062	635,900	825,408

Cordoba.—This company was formed by John Taylor & Sons in 1908 as a consolidation of the Cerro Muriano and North Cerro Muriano companies, operating copper mines in the south of Spain, 10 miles northeast of the city of Cordoba. Dividends were paid for the years 1912 and 1913. The report for the year 1914 shows that the grade of the ore has become lower, and during the 7 months before the war the average monthly output of blister copper was only 228 tons, as compared with an average of 290 tons during 1913. On the outbreak of the war, the sale of the copper was interrupted, so that mining and smelting had to be suspended. Subsequently conditions changed, and smelting was gradually resumed, until an output of 150 tons per month was attained. The ore raised during the year was 87,870 tons, averaging 2.78 per cent. copper. The yield of blister copper was 1941 tons. During 1913 the output of blister copper was 3500 tons, and the ore mined was 119,069 tons. The ore reserve on December 31 was estimated at 155,270 tons averaging

2.87 per cent. copper, as compared with 206,489 tons averaging 3 per cent. at the end of 1913 and 200,025 tons averaging 3.35 per cent. at the end of 1912. As has previously been recorded, the Murex wet magnetic process was adopted at the mine a few years ago. During 1914 this plant treated 17,435 tons of middling and slime averaging 1.14 per cent. copper, for a yield of 1232 tons of concentrate averaging 9.5 per cent. copper. The assay of the tailing was 0.49 per cent. copper, and the recovery was 58.8 per cent.

Tharsis.—This company, with headquarters in Glasgow, operates the Tharsis and Calanas sulphur and copper mines in the south of Spain. As the pyrite is shipped chiefly to England and Scotland, no great inconvenience has been experienced from the war. But the low price of copper adversely affected the profits. The shipments of pyrite amounted to 501,037 tons, as compared with 508,287 tons in 1913, and, in addition, 1611 tons of copper precipitate was shipped, as compared with 1534 tons in 1913. The total production of refined copper from pyrite and precipitate was 3605 tons, as compared with 3218 tons in 1913, though the increase was more than accounted for by purchases of precipitate.

Mason & Barry.—This company was formed in 1858 to acquire the San Domingos sulphur and copper mine at Mertola, Portugal, just over the Spanish border, on the same mineral belt as the Rio Tinto and Tharsis. In the year 1878 the company was expanded and public subscriptions invited. At the outbreak of war, the German market for pyrite used in sulphuric acid manufacture was lost, and the output was consequently restricted. The report for the year 1914 shows that 259,238 tons of ore was raised, as compared with 378,929 tons the year before.

Venezuela.—The production of copper in Venezuela is not separately reported and has been small in recent years, but prospects for the future seem encouraging. Only ore averaging about 8 per cent. copper is sent to Europe for treatment, but provision has lately been made for the erection of a smelter to treat the low-grade ore, which will increase the output considerably.

The South American Copper Syndicate, operating the Aroa group of mines, started its new smelting plant in the spring of 1914, but the preliminary difficulties incident to starting the new works carried the company operations into the period affected by the war and the year was not a prosperous one, as production was then reduced to a minimum. Besides the old Aroa mine, the company was preparing to stope ore in the Aroa North and the Titiara mines. In the latter half of the year mining was restricted to a production just sufficient to pay for the operations. The Cumaragua company, of Caracas, continued the

exploration of its group of mines in the Aroa district, power drills having been installed; the old copper mines at Buria, near Nirgua, were also under development.[1]

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The Pyrometallurgy of Copper in 1914

By L. S. Austin

Progress in 1914.—The new method of charging blast furnaces at the Calumet and Arizona smelter consists in delivering both ore and coke to overhead feed-bins, whence charges may be withdrawn to charge-cars. These cars when charged move forward but a short distance, discharging into the furnace. Charge-trains are eliminated.

Roasting furnaces of the multiple-hearth type, as much as 22½ ft. diam. and with seven hearths, are giving creditable outputs.

While increasing use is being made of the reverberatory furnace, the Detroit Copper Mining Co. has just built a new 44 in. by 33 ft. blast furnace, run at the low pressure of 14 oz., to treat concentrates produced by their mill. It was thought better to do this than to put in the more expensive reverberatory equipment.

Root blowers of 400 cu. ft. displacement per revolution are now in use.

Decided improvements are being made in reverberatory work, due to the successful application of powdered-coal firing. The amount needed per ton of charge has been reduced to as low as 13.3 per cent. with an output of 450 tons daily in a 19 by 112-ft. furnace. A novel feature is the charging of materials on the two sides, at once fettling the furnace and extending the melting surfaces.

A large furnace, 25 ft. wide by 144 ft. long, is being constructed for coal-dust firing. It is expected to be quite as economical of fuel as any, and to have an output of not less than 800 tons daily.

This advance in practice is destined to cause changes by increasing the field of use for reverberatories as compared with blast furnaces. It is now possible to give the former a preheated, regularly-fed charge, to maintain the furnace at a uniformly high temperature, and to feed both coal and air in regular proportion and amount, so that the irregularities, as found in natural-draft coal-firing, no longer exist. The low cost for fuel is, however, the controlling factor, especially when we remember that the waste-heat boiler also aids in the economy.

In converting, control of temperature has been found to be an important factor in creating and maintaining a magnetite lining unattacked by the molten matte. At the International plant, Tooele, Utah, Kucks has been successful in treating leady copper matte, using a bag-house to recover the volatilized lead, and blowing the high-grade lead-free matte with reverberatory furnace matte to recover the copper in the slag and to produce a regular blister copper.

Roasting and Sintering

Sulphur Limit for Self-roasting.—In multiple-hearth furnaces this is generally reckoned at 26 per cent. below which fuel is needed to maintain the roasting temperature. At two works in the Salt Lake Valley it has been found possible to roast matte of 20 to 24 per cent. sulphur in Wedge furnaces. To do this, fuel is used in the fire-boxes until the furnace is fully heated, then, with a large feed and increased speed of the rabbles, fuel can be gradually decreased and finally quite omitted.

At the Humboldt Smeltery,[1] where Wedge furnaces are used, about 110 tons daily per furnace are put through without the use of fuel, the charge consisting of a mixture of concentrates, limerock and basic ore of an average of 22 per cent. sulphur, and this is roasted to 5 per cent. in the calcine.

Roasting Copper-Nickel Matte.[2]—Experimenting on a finely ground matte of Ni 54, Cu 24, S 16.5 per cent., roasting proceeds slowly below 600° C.; above 730° C. the particles agglomerate, preventing further roasting. However, by roasting first at 450 to 500° C. with vigorous rabbling, so that the particles are coated with a layer of oxide, the roast may be safely completed at 675 to 725° C. At between 525 and 600° C. some copper and nickel sulphates form, but are broken up above 650° C. into oxides. The reaction between the nickel sulphide and the copper oxide gives a mixed sub-sulphide and a cuprous sulphide, the latter forming rapidly at rising temperature. Nickel sub-sulphide is then quite stable and not decomposed in the presence of copper oxide.

The Herreshoff Roaster.[3]—In addition to the description of this furnace given in Mineral Industry, **22**, we add these further details:

Each furnace is estimated to require 3 h.p. for operation, and 2400 cu. ft. of air per min. This is supplied to eight furnaces by a 55-in. Buffalo fan run by a 24-h.p. electric motor. The rabble teeth are provided with means of setting them all at the proper feeding angle. The peripheral feed openings of the second and fourth roasting hearths are 54 in number,

[1] *Eng. Min. Jour.*, **98**, 425.
[2] *Sch. of Mines Quart.*, Nov., 1913.
[3] *Eng. Min. Jour.*, **97**, 262, 1283.

each opening being 14 by 8 in. The central openings of hearths one, three and five are 8 ft. diam. Ample edges are thus given over which the ore is showered to the next hearth, but of course with the production of much flue dust. The capacity per furnace is given at 70 to 100 tons daily.

Blast Furnaces

Pyritic Smelting.[1]—The smelteries of the Tennessee Copper Co. and the Ducktown Sulphur, Copper and Iron Co. in Polk County, Tenn., afford the best examples of pyritic smelting. The advantages of pyritic smelting over roasting and smelting are: (1) heap-roasting, costing 35 cts. per ton, is omitted; (2) saving of interest on the time the ore is roasting, say 3 months; (3) fuel-saving of coke, say 6 per cent.; (4) removal of the fumes from the top of the stack and not from the ground; (5) fast running. On the other hand, more flux is required and more slag is made than in ordinary matte smelting.

Under best working conditions, smelting an ore of 1.75 per cent. copper, the following equation is expressive:

Ore.	Quartz.		Matte of 21 Per Cent. Cu.		Slag.		Escaping SO_2.
$(80FeS)(Cu_2S)$	$+ 75SiO_2$	$+$ air $=$	$(5FeS)(Cu_2S)$	$+$	$75FeO.SiO_2$	$+$	$75SO_2$

If the quartz be increased to 76 per cent. SiO_2 the grade of matte will go up to 25 per cent. Thus the more quartz carried the higher the grade of the matte; but on the other hand, as concentration increases the greater becomes the slag loss in copper.

Quartz carrying much alumina is not as satisfactory as a pure, non-decrepitating lump quartz.

With clean sulphides and a pure quartz a range of concentration is possible of from two to forty into one. At the lower limit the reactions will not maintain temperature; at the higher, the furnace refuses to melt all the quartz, and this accumulates and eventually makes trouble.

In ordinary matte smelting the ratio of sulphur to copper may be 3 to 1; in pyritic smelting 15 to 1; so that more air is needed. But the overplus of increased air is slight, due to increased oxygen efficiency as the higher-grade mattes are made. That is, more of the air is used; less escapes unused; also as higher-grade matte is made, the focus of the furnace has a higher temperature, due to the faster running. A more basic slag is made, and the higher the temperature, the more basic the slag. Siliceous slags form at a lower temperature, therefore, in a hot furnace, more iron is taken up by silica, the slag is more basic, and the matte, thus robbed of iron, is of higher grade.

[1] *Proc. Can. Min. Inst.*, 1914; *Eng. Min. Jour.*, **98**, 1134; *Trans. Min. Met. Soc. of Amer.*

If the sulphide ore contains much gangue (silicates of iron, lime, alumina and magnesia) it seems at times to support two slag-forming foci, the upper producing from the gangue a thick viscous slag, the lower or ordinary focus the typical thin, hot pyritic slag. If these two foci coincide there is smooth running; otherwise not.

In a typical example, using 4.15 per cent. of coke and with a matte-fall of 10.5 per cent., the escaping gases had the composition by volume: CO_2 4.2 per cent.; SO_2 7.5; O 6.7; N 81.6 per cent.

At a meeting of the Mining and Metallurgical Society of America,[1] Mr. Sticht related conditions at Mt. Lyell: The smelting column is 18 ft., and a blast-pressure of 64 oz. per sq. in. is carried. It is assumed that the furnace is filled with a honeycombed mass of quartz, the blast and the molten sulphides moving in opposite directions, the incandescent silica, by catalysis, oxidizing the sulphides in presence of the air, and the resultant FeO uniting with the silica to form a slag. The matte will vary from 35 to 65 per cent., but is generally 45 to 50 per cent. Cu. When the matte runs high the proportion of silica is reduced, and *vice versa*. Due to the present greater proportion of silica and lessened iron and sulphur in the ore, as compared with early practice, 3.5 to 5 per cent. of coke of an inferior grade must be used. Slags go 35 to 37 per cent. SiO_2, as against 30 to 32 per cent. in the past. He thinks in his practice that the shape of the furnace is secondary—the furnace makes its own lines. The focus or smelting zone can be driven upward by increased blast, and indeed even to the top of the ore-column. The furnaces are individually run as respects charge-composition, and in operation the feeding is a principal factor.

J. Parke Channing stated that W. H. Freeland undertook pyritic smelting about 15 years ago, but was unsuccessful until he cut the coke to a minimum, and added silica to the charge. Mr. Channing successfully followed this practice, but with the production of little better than a 10 per cent. matte, which had to be concentrated in a second furnace. However, the extraction, as compared with roasting and smelting, was better. The company now makes sulphuric acid, and needs a gas from the furnaces of close to 6 per cent. SO_2 and 9 per cent. oxygen. If the SO_2 is high and the oxygen is low it hardly will do to add air, since that also introduces inert nitrogen as a diluent, bringing the SO_2 below the working requirements. The best way is to keep the coke at a minimum, so that less air will be used up in burning it.

D. H. Browne stated that, despite the efforts of himself and Mr. Guess, they had been unable to smelt pyritically Sudbury ores containing 35 per cent. Fe and 20 per cent. S. Mr. Sticht thought better success

[1] *Trans. Min. Met. Soc. Amer.*, 7, 197.

would result from having the ore more lumpy, and by using pure silica rather than the bisilicates. To his mind pyrrhotite should smelt as well as pyrite. He emphasized the need of an 18-ft. column, and a consequent high pressure. He uses 20,000 cu. ft. of air per min. per furnace. No oxygen is found in the escaping furnace gases, nor in them at a point 7½ ft. below the top of the column. With pyrite the furnace runs with a hot top.

Magnetite Formation in Furnaces.[1]—We have already given the method of forming a magnetite lining in converters. J. W. Bennie, manager of the Shannon Copper Company, discusses their formation in furnaces. In roasting ores in the multiple-deck furnaces, if the temperature of the mixture of oxides and sulphides of the partly roasted ore is suddenly raised, there occurs the reaction: $FeS + 10\ Fe_2O_3 + SO_2$, and this reaction may, no doubt, occur in blast furnaces. Metallurgists also hold that the further reduction to ferrous form occurs according to the endothermic reactions:

$$(1)\ FeS + 3\ Fe_2O_3 = 7FeO + SO_2,$$
$$(2)\ FeS + 3\ Fe_3O_4 = 10FeO + SO_2,$$

and that, in pyritic smelting with a plentiful excess of air, ferrous sulphide is burned, as given by the formula:

$$(3)\ FeS + SO_2 = Fe_3O_4 + 3SO_2.$$

Some years ago at Mt. Lyell, Tasmania, in the concentration of the first matte, large quantities of magnetite were formed soon after blowing in, and unfused silica accumulated, so that in 4 to 6 days the furnace had to be shut down. For all that, the management thought the saving in cost, due to the rapidity of concentration, justified so short a campaign.

Mr. Bennie gives his experience at a Pacific Coast plant, treating a cuprous-iron sulphide containing 7 to 8 per cent. copper and 45 to 48 per cent. sulphur. The ore was stall-roasted. Sometimes roasting was so imperfectly done as to yield a fused product, a low-grade matte in fact, which contained 20 to 23 per cent. sulphur. This, when broken by blasting to the proper size, was sent to the blast furnace and smelted, using 10 to 12 per cent. of a high-ash coke with a 7-ft. ore column, but with a short campaign terminating in a frozen furnace. The stages were first the production of an excessive amount of low-grade matte, the rapid falling off of the volume of slag, and the thickening and sudden increase in the grade of the matte until the end of the run. The higher-grade matte carried as much as 20 per cent. Fe_3O_4. On opening the furnace, accretions were found from the tuyère-level to 3 or 4 ft. above it, con-

[1] *Eng. Min. Jour.*, **96**, 1213.

sisting of unfused quartz and limestone surrounded with magnetite, this latter due to the oxidation of the iron sulphide at too low a temperature to form slag, as indicated in reaction (3). The change of magnetite to the ferrous form will depend therefore on the presence of carbon, or of sulphide at a sufficiently high temperature to ensure slag formation.

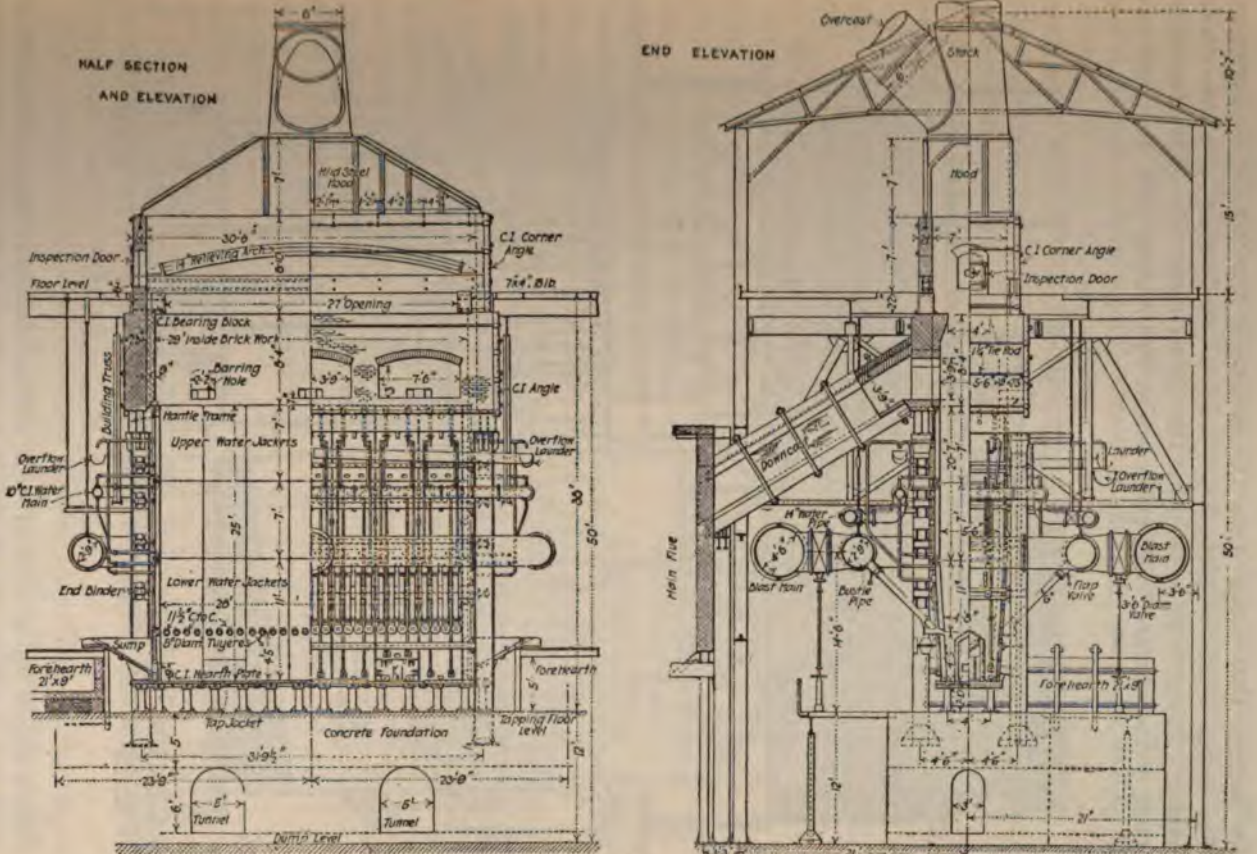
Granulating Matte.[1]—R. L. Hallett describes the method of the Consolidated Arizona Smelting Company's plant at Humboldt, Arizona. The low-grade matte, flowing from the tap-hole of the matte-pot, is struck and granulated by two horizontal water jets and swept into inclined-bottom tanks. The granulated material is drawn off by a gate and chute into tram cars.

Slag-spout.[2]—A trough-shaped steel spout is used at Morenci, Ariz. Either end may be fitted to the breast. When in use a clay door is built at the front end. In case of emergency this may be torn down and the furnace drained. No water-cooled nose is needed.

Mt. Morgan Blast Furnace.[3]—There are three 54 in. by 28 ft. blast furnaces, connected by a flue 560 ft. long to the main dust-chamber 47 ft. wide, 31 ft. high and 70 ft. long, thence, by an existing flue, to a main stack 250 ft. high by 11 ft. inner diam. There are 20 storage-bins grouped in a block of four by five rows, and having inclined bottoms.

The furnaces are arranged axially with the length of the building at 70-ft. centers on a continuous concrete foundation 12 ft. high above the dump level, as shown in the elevations at Figs. 1 and 2. The slag-trains travel on a track parallel to the furnaces. These trains have side-dump bowls of 20 tons and end-dump bowls of 10 tons capacity, and are handled by a steam locomotive. The fore-hearths, one at each end of the furnace, are set transversely to discharge into the slag-bowls. Tunnels in the foundation afford protected access to the slag-trains. The furnace shaft has but a 5-in. bosh, and is water-jacketed to a height of 25 ft. with three tiers of jackets. Just above these the gases are mostly taken off at the side by a rectangular brick down-take to the main flue. On the wall opposite are barring-holes by which the down-take is cleaned. Each furnace has its own bustle-pipe, connected on opposite sides to the two blast-mains, so as to ensure an abundant supply of air. There are 56 tuyères, 5 in. diam., or rather larger than in American practice. These enter the furnace at the usual height of 53 in. above the hearth-plate, due to the deep slag spout and sump employed. At the charge-floor the furnace is narrowed to 48 in. The feed doors or openings, nearly the length of the furnace, are 22 in. high. At this height is a floor

[1] *Colo. Sch. of Mines Mag.*, Jan., 1914.
[2] *Eng. Min. Jour.*, **98**, 353.
[3] *Eng. Min. Jour.*, **98**, 570; *Queensland Govt. Min. Jour.*, Nov. 14, 1914, p. 565.



FIGS. 1 and 2.—Mt. Morgan blast furnace.

for buggies that dump upon the feed-plate next to the feed opening. The charge when complete is pushed into the furnace by a mechanical pusher. It may thus be seen that this allows of any desired prior arrangement of the charge. The gases, which rise through the 4-ft. feed-slit,

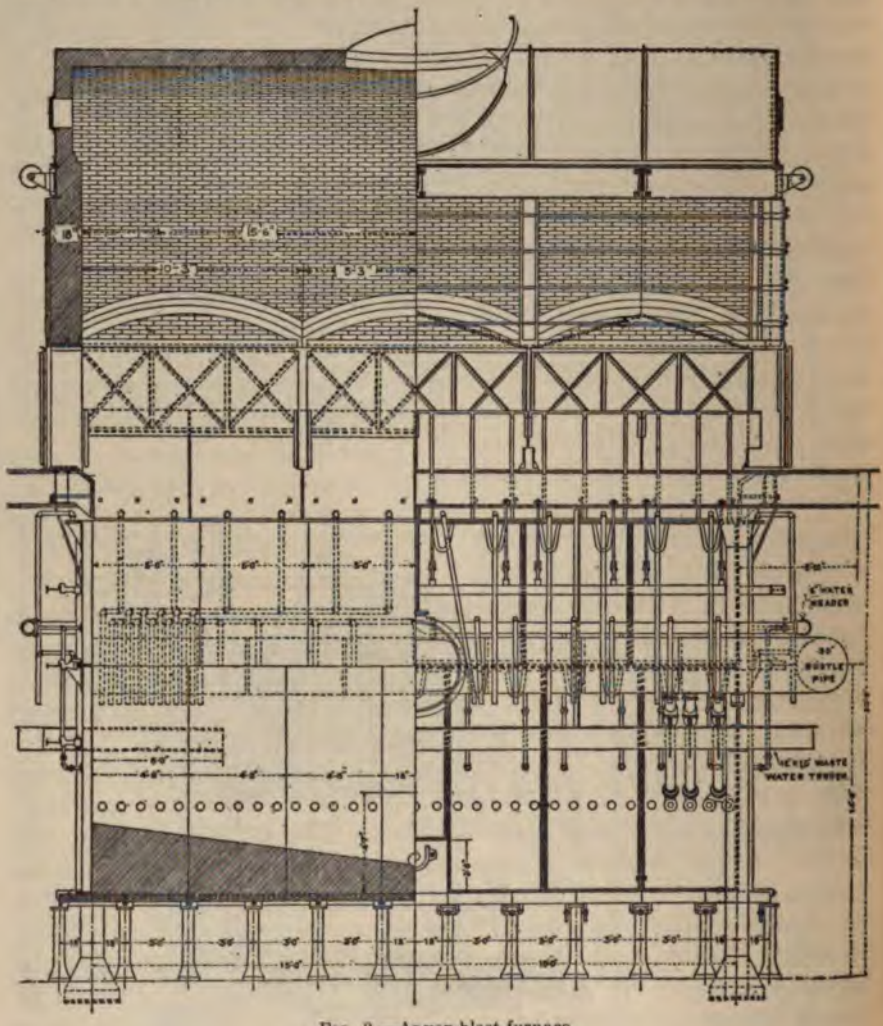


FIG. 3.—Anyox blast furnace.

enter a closed top or hood of steel, and are carried by an overhead goose-neck (overcast) to the flue. An inspection door at each end of the furnace is used for noting its condition. The straight stack above the goose-neck is opened where the furnace is run down.

Blast Furnace of the Anyox Smeltery.[1]—The plant contains three 50 in. by 30 ft. blast furnaces, built by the Traylor Engineering & Manufacturing Company, and is shown in longitudinal section and elevation in Fig. 3, and in transverse section and elevation in Fig. 4. The water-cooled sole-plates standing 4 ft. above the slag floor are supported by 24 columns at 3-ft. centers. The crucible is lined with a fire-brick bottom sloping to the tap-hole at the middle of the side. The jackets in two tiers, boshed 11 in., rise to cast-iron cheek-plates, and with the distributing plates complete the height of 26 ft. 4 in. to the feed-floor. On each side of the furnace are six lower jackets, each 54 in. wide, and one tap-hole jacket 36 in. wide. The upper jackets are 60 in. wide. There are 33 tuyères to the side. To prevent the jackets bulging, a binder frame is built around the furnace from column to column. Cast-steel spacing rods or struts (see Fig. 4) extend from this frame to each jacket, fitting into sockets that are riveted to the jacket. Wedges, driven in behind the strut, tighten up the jacket. Thus one jacket can be taken down without disturbing the others. On the middle of one side is a trapped spout, on the other a short spout for draining the crucible.

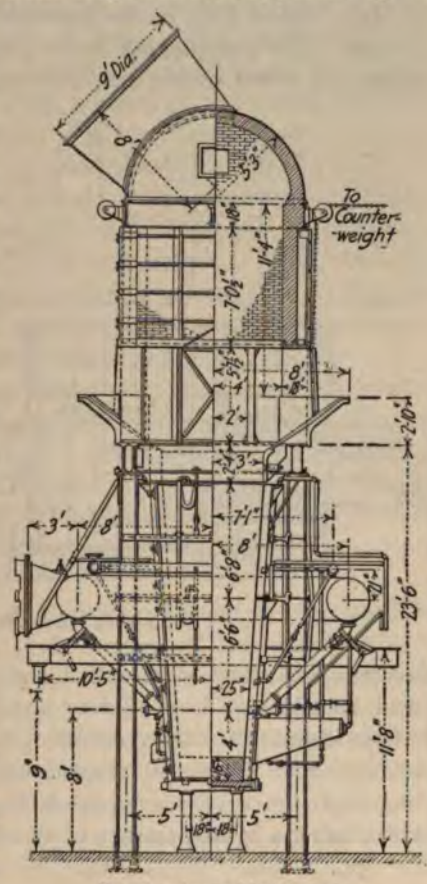


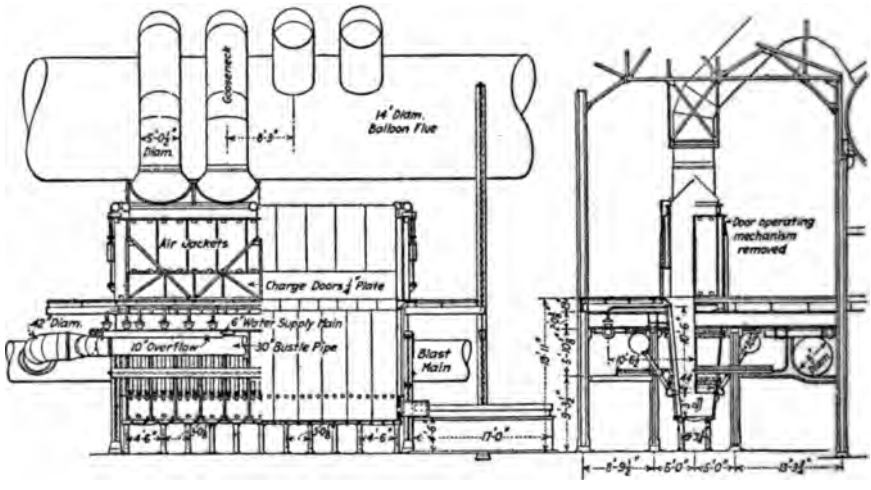
FIG. 4.—Anyox blast furnace.

The furnace above the feed-floor is surmounted by a closed top of brick from which leads off a 9-ft. steel goose-neck down-take. The six feed-doors on each side are counter-weighted, and there is an observation door at each end.

Blast Furnace of the Detroit Copper Mining Co.[2]—This 44 in. by 33 ft. furnace has been especially designed to smelt concentrates, and is operated under low pressure to avoid excessive production of flue dust.

[1] *Can. Min. Jour.*, Nov. 1, 1914, p. 701.
[2] *Eng. Min. Jour.*, **98**, 199.

Figs. 5 and 6 give transverse and longitudinal sections and elevations of the furnace, which carries not to exceed 10½ ft. of a smelting column. The sole-plates are of cast steel but not water-cooled; the furnace bottom is lined with chrome brick set on end on a 4½-in. layer of fire brick. On each side of the furnace are eleven straight jackets, 3 ft. wide by 13½ ft. high, boshed 13½ in. to increase the surface width of the top of the charge. The end-jackets come down only to the tuyère level, below which is a water-cooled cast-iron tap-jacket. The superstructure of the



FIGS. 5 and 6.—Detroit blast furnace.

furnace is of sheet steel with an air space of 8 in. The top is in gable form, from which lead off four goose-neck down-takes by a 14-ft. diam. balloon-flue to the dust-chamber. This is of hollow tile with a reinforced concrete roof having suspended wire baffles. The dust is removed by drag-chain conveyors (see page 244). The furnace puts through 440 tons daily, using a blast-pressure of 14 oz.

REVERBERATORY FURNACES

Coal Economy and Efficiency in Reverberatory Smelting.[1]—C. D. Demond discusses this broadly: The better grades of coal are often the most economical, but freight charges greatly modify the price, so that a poorer grade near by may be better employed.

Efficiency depends on maintaining a temperature in the furnace as high as possible above the critical temperature. Thus, if the slag-formation temperature is 1100° C., then a coal that maintains a temperature

[1] *Bull. Amer. Inst. Min. Eng.*, Aug., 1914, p. 1847.

of 1500° is at least four times as efficient as one that can raise the temperature to 1200° C. only.[1]

An attempt to use coal from Belt, Mont., containing 25 to 30 per cent. ash, in a 20 by 12 ft. reverberatory furnace, and having a grate area of 20 sq. ft., was unsuccessful, due to the following reasons: (1) There was a large loss of coal from the grate because the ash did not clinker and the draft was enough only for a thin bed of coal. (2) The volatile combustible was too low to produce a good flame on the hearth, and the heating value of the coal was low. (3) The large amount of ash mixed with the true coal prevented efficient combustion. With a 40-sq. ft. fire-box and forced draft, however, enough flame was driven into the hearth to maintain smelting conditions, and a clinker-bed could be carried to prevent loss due to dropping coal. However, forced draft caused troublesome sinter, though a steam jet was applied in the ash-pit. Even then the grate had to be dumped and a new fire started every 12 hr. By the use of a Diamondville coal natural draft could be used with a 40 per cent. decrease of fuel and an increased output of 66 per cent.[2]

A trial of Belt coal with a large reverberatory and with a strong natural draft was no more successful, though 98 tons was used per 24 hr. With forced draft and carrying a 7-ft. bed of coal, 19 per cent. less coal was used and the output increased 12 per cent., but even then results were not equal to those of good coal. Besides this was to be reckoned the additional cost for forced draft and the steam used to prevent clinkering.

Rock Springs coal was tried but, though of good grade, has the drawback that it flashes too much, that it gives off its volatile matter so rapidly that there is a good flame for a few minutes only, and but little for most of the time.

Four factors in coal affect smelting efficiency, viz.: (1) the character of the true coal substance, (2) the percentage of fine coal, (3) the percentage of moisture, (4) the character and percentage of ash.

Of the character of the true coal substance something can be judged by the proximate analysis. However, the volatile combustible will

[1] Some authorities state that this efficiency varies more rapidly than this, the difference increasing, as expressed graphically, by a parabolic curve.

[2] The proximate analysis of the two coals discussed are:

	Moisture, Per Cent.	Volatile Combustible, Per Cent.	Fixed Carbon, Per Cent.	Ash, Per Cent.	Calorific Power.
Belt	8.5	23.6	38.7	29.2	4545 Cal.
Diamondville	8.0	36.6	45.4	10.0	6210 Cal.

vary in hydrogen, in sulphur, and in the amount and nature of the volatile hydrocarbons. These latter vary with the volatilization temperature, moderate temperature yielding large quantities of heavier products, while very high heats give more of the lighter products. The light gases burn with a clear blue flame, the heavier products with an opaque yellow or white flame, due to the incandescence of solid particles. It is these particles that efficiently radiate heat to the charge, and no doubt also transmit to the charge the heat evolved by the clear flame.

The causes of reduced efficiency, due to a large percentage of fines in the coal, are that the fresh supply of coal temporarily smothers the fire and lessens the draft through it, while the large surface of fine coal permits the evolution of more volatile matter than there is air for, so that some escapes unconsumed. Also much fine coal drops through the grate. At Anaconda this may be as much as 25 or 30 per cent. when using much fine coal or an insufficient clinker bed, but only 12 to 15 per cent. with proper coal. Finally the bed is likely to burn into holes where unnecessary air can enter.

Six per cent. of moisture in a pound of coal needs 65 pound calories to evaporate it. This may reduce the furnace temperature 15° C. and probably reduces efficiency by at least 3 per cent.

Ash, when it does not sinter badly, furnishes a bed of clinker that prevents the serious dropping of coal, and in this respect is a benefit. In using Diamondville coal at Anaconda under forced draft, after the grate was cleaned, a tremendous volume of dense flame was evolved, due to the high temperature in the fuel-bed; but this high temperature gradually covered the grate with a dense clinker, the passage of air was reduced, and there was little flame in the furnace. The grates had to be cleaned every 4 hr. Introducing steam under the grate did not help much. Clinkering depends on the fusibility of the ash.

Reverberatory Firing with Powdered Coal.[1]—The preparation of powdered coal and the practice of burning it has been borrowed from the clinker-burning in cement manufacture. At the Washoe plant, Anaconda, the coal is thus prepared:

Run-of-mine coal from a storage bin is fed to a 30 by 30 in. Jeffrey single-roll coal crusher and reduced to 1-in. size. Passing over a Dings magnetic pulley, which removes any bolts or pieces of iron, it is fed to a Ruggles-Coles double-cylinder dryer 40 ft. long by 6 ft. 8 in. diam. Here it is dried to 1 per cent. or less of moisture at the rate of 18 tons per hr., using about 1.5 per cent. of lump coal for drying. It takes a particle 30 min. to pass through the dryer. The gases are drawn through

[1] *Bull. Amer. Inst. Min. Eng.*, March, 1914, p. 369; Jan., 1915, pp. 49, 73; *Eng. Min. Jour.*, **98**, 725; *Jour. Am. Soc. Mech. Eng.*, **36**, 337; Private Notes.

the dryer by a 72-in. Sturtevant fan to the stack. The dried coal goes to a steel bin whence it is fed to a Raymond five-roller pulverizing mill of an hourly capacity of 4½ tons. As quickly as reduction occurs the fine dust is taken away to a Cyclone dust collector placed 20 ft. above the pulverizer, the coarser material remaining in the mill until fine enough. The finished product is discharged at the bottom of the dust collector and taken to the feed-bins at the furnaces. Following is a screen analysis of the powdered coal:

	Plus 100, Per Cent.	Minus 100, Per Cent.	Plus 200, Per Cent.	Minus 200, Per Cent.
Lochray	2.3	97.7	12.1	85.6
Bear Creek	4.4	95.6	21.8	73.8
Diamond	6.1	93.9	18.5	74.4

When coal is used in powdered form, all the fixed carbon, as well as the heavy volatile hydrocarbons, and even the ash, supply incandescent surfaces for the radiation of heat to the charge; there is no ash-pit loss as in grate coal-firing, and the conditions of air and fuel supply are uniform, and can be nicely adjusted for the best results. Recent practice, in which a coal was used having 7.5 per cent. of +100 mesh, 21.1 per cent. of +200 and 71.4 per cent. of −200 mesh, has been found to work as well as the finer-ground coal in this long furnace.

At Garfield, Utah, where charging is done in the usual way mainly toward the fire end, the furnaces, 19 by 110 ft. hearth area, have melted 400 tons daily, using 14.5 per cent. coal-dust. The slag has averaged SiO_2 42, FeO 38, and CaO 13 per cent. Analysis of the coal there used shows: moisture 7 per cent., volatile combustible 46.5 per cent., fixed carbon 48 per cent., and ash 6 per cent., with a calorific value when dry of 7500 Cal. This is to be compared with oil-firing, where 365 tons was smelted daily with a consumption of 0.63 bbl. of fuel-oil per ton of charge.[1]

The conditions for successful coal-dust firing are:

1. The coal, before grinding, must be dried to 1 per cent. or less.

2. It must be finely pulverized as indicated by the screen analyses above given. With this fine grinding an enormous increase of surface is obtained, so that the coal is quickly and completely burned.

3. Both the delivery of coal and air must be capable of complete regulation.

4. The coal must contain enough volatile combustible matter, though as little as 22 per cent. has been successfully used in cement practice.[2]

[1] A fair average cost for grinding the coal may be given at 35 to 40 cts. per ton or 5 to 7 cts. per ton of ore smelted.

[2] James Lord, of the American Iron & Steel Company, recommends 30 per cent. as the minimum.

5. The furnace must be properly proportioned, properly equipped and in good condition.

6. Suitable provision should be made for taking care of the ash.

Reverberatory Coal-dust Firing of the Canadian Copper Co.,[1] *Copper Cliff, Ontario.*—Originally built in 1911, the furnaces of the Company have been somewhat modified. Directly over the side walls at the fire end, large bins discharge into small hopper-bottom cars which run on 24-in. tracks. Under these tracks a long trough extends at each side just above the side walls, into which the cars deliver. The trough has openings at 2-ft. centers for 6-in. iron pipes passing through holes in the roof and regulated by a slide. The ore falls down, covering the side walls as shown in Fig. 7, a cross-section of the Anaconda furnace. The pipes form a continuous line the length of the furnace, so that ore is fed along one side clear to the throat, but on the slag-tap side only to the tap-hole. The furnace has no side doors. Most of the ore is fed at the sides, the remainder by two large hoppers through six openings at the fire end. Thus protected by ore, a basic bottom is no longer needed, and has been replaced by the usual sand bottom.

The furnaces are set at 56-ft. centers on a slag-block 11 ft. above the yard. Midway between the furnaces are tunnels 12 ft. wide to carry tracks for the 25-ton matte cars.

The furnace roof is of silica brick 20 in. thick, and toward the fire end averages 7 ft. 10 in. above the bottom for a distance of 34 ft. It then drops in 12 ft. to the height of 6 ft. above the hearth, or to 4 ft. 10 in. above the skimming line, so continuing to the flue end. This lower roof is of 15-in. brick. The two matte tap-holes are on opposite sides, 34 ft. from the fire end. From the throat a straight flue, 8 ft. 8 in. wide, leads to the boilers and stack. This provides for the proper escape of the ash from the powdered coal. The skimming door is placed at one side, 16½ ft. from the throat. A clay-lined slag launder carries the slag to the 25-ton slag-pots, brought in on a track at right angles to the furnace and under the outlet flue.

The coal-dust is introduced through five air pipes, 5 in. in diam., set 3 ft. 2 in. above the hearth, and about 2 ft. above the skimming line. From the pulverized-coal bin the powdered coal is fed by Sturtevant automatic-feed screw conveyors into the air nozzles about 2 ft. from the furnaces. Any conveyor can be stopped, and the coal delivery pipe can be closed by a slide-gate. As a rule all five burners are in operation, each delivering about 13.5 tons of coal dust per day, making a total of 67 tons per furnace. Air is supplied in quantity to blow the coal into the furnace, and additional air is supplied by openings in the end wall,

[1] MINERAL INDUSTRY, 21, 246; *Bull. Am. Inst. Min. Eng.*, Jan., 1915, p. 49.

egulation being by loose bricks suitably placed in the openings. The lraft at the fire wall is 0.25 in., at the throat 1.2 in. of water. Combustion is good.

On one 10-day test the following averages are given:

Coal consumption in tons in 24 hr.	69.7
Gas temperature at the throat in degrees C.	922.0[1]
SO_2 and CO_2, per cent.	12.3
Oxygen, per cent.	6.5
SO_2, per cent.	1.14

The average daily charge was 409 tons using 17 per cent. coal. In March, 1914, the consumption fell to 14.6 per cent.

Slack coal is used, having the analysis: volatile matter 34.7 per cent.; ixed carbon 55.4; ash 9.25; sulphur 1.3 and moisture 4.31 per cent., with a hermal value of 7500 Cal. The ash causes but little trouble. A small mount settles on the slag, a little in the flue, and a few hundred pounds nay stick around the throat as a light pumice-like mass, and this is leaned off daily at a small door beneath the throat.

The maximum depth of matte and slag is 22 in., and 8 in. of matte is arried at a point 6 in. below the skim plate. As the charge at the side valls occupies much room, there is never more than 40 to 50 tons of slag n the furnace.

Reverberatory Coal-dust Firing at Anaconda.[2]—Following its successful peration at the works of the Canadian Copper Co., a furnace was renodeled at Anaconda for coal-dust firing. It is 124 ft. long, 21 ft. wide, nd varies in height from 8 ft. 6 in. at the fire end to 5 ft. 7 in. at the kimming end, and has a roof 20 in. thick. Otherwise it is constructed ike the older furnaces (see MINERAL INDUSTRY, **15**, 275). By shutting ff the burners for a few seconds, so that the gases in the furnace may lear away, the interior can be inspected. As at Copper Cliff, charging s done on either side of the furnace from longitudinal hoppers extending 4 ft. from the fire end. Leading from the hoppers at 19¼-in. intervals re 6-in. pipes through which the charge is intermittently dropped, thus eeping the side walls covered above the slag line. Beyond this the urnace requires fettling, since in 3 months the side walls were corroded to a depth of 8 in. at the front end, this diminishing to nothing 0 ft. back. At the end of the 3-month period the roof was in good ondition, at 30 ft. from the fire end eaten away 2 in., but at 60 ft. not at ll. The matte tap-hole was at first 83½ ft. from the front end, and the harge could not be dropped over or near it. Still the matte would not ll drain to this point and the matte tap-hole was finally changed to the ront end at the side of the skimming door and at the level of the bottom.

[1] A temperature of 922° C. seems low as compared with the general practice of 1200 to 1300° C. However, it is claimed that the heat has been largely taken up in smelting ore along the side walls and o the gases escape that much cooler.

[2] *Eng. Min. Jour.*, **98**, 725; *Bull. Am. Inst. Min. Eng.*, Jan., 1913, p. 73.

Banked at the fire end and sides as the furnace is, the matte naturally runs to the front. The furnace, charged in the old way, would hold 175 tons of matte, now it will hold but 50 tons. Some 35 tons is tapped per shift. The furnace is skimmed three times per 8-hr. shift. There are two flue connections to either of the two batteries of Stirling boilers; one of the flues has a sectional area of 13.5 sq. ft., the other of 40 sq. ft. The smaller flue is used when the other battery has to be cleaned out. This cleaning, which occurs monthly, takes 3 days, and production drops off. Thus for 3 days before cleaning 497 tons would be smelted daily, using nearly 15 per cent. of coal; at cleaning time 405 tons would be smelted, using the same quantity of fuel; for 3 days immediately after, the production would rise to 539 tons and the fuel would drop to 13 per cent. A daily output, lasting for a week, has been made of 542.7 tons, using but 13.3 per cent. of coal dust. This result can be compared with a former daily output of 260 tons and a coal consumption of 24.1 per cent. in the same sized natural-draft coal-fired practice.

The method of feeding the powdered coal is the same as at Copper Cliff except that five 6-in. burner pipes are required. The port-holes around each pipe are 12 in. in diam., the annular space being dampered to regulate the admission of secondary air. Four port-holes, between and above the burners in the end wall, supply further air there, the size of these openings being regulated by inserting bricks. The coal feed is regulated by means of a Reeves variable speed regulator.

To remove the ash accumulating in the flue between the furnace and the boiler needs two men working 4 to 6 hr. per day. Using coal of 22 per cent. ash, giving a light fluffy product, gave less trouble than when using a coal of 9 per cent. ash yielding a slightly sintering product. In September, 1914, the flue yielded for the month 85.54 tons of ash and flue dust of the composition Cu 3.1 per cent., SiO_2 36.5, FeO 10.3, CaO 7.0 per cent., together with Ag 5.3 oz. and Au 0.019 oz. per ton. About as much more ash falls upon the molten bath and is there absorbed. Very little of the ash goes to the boilers.

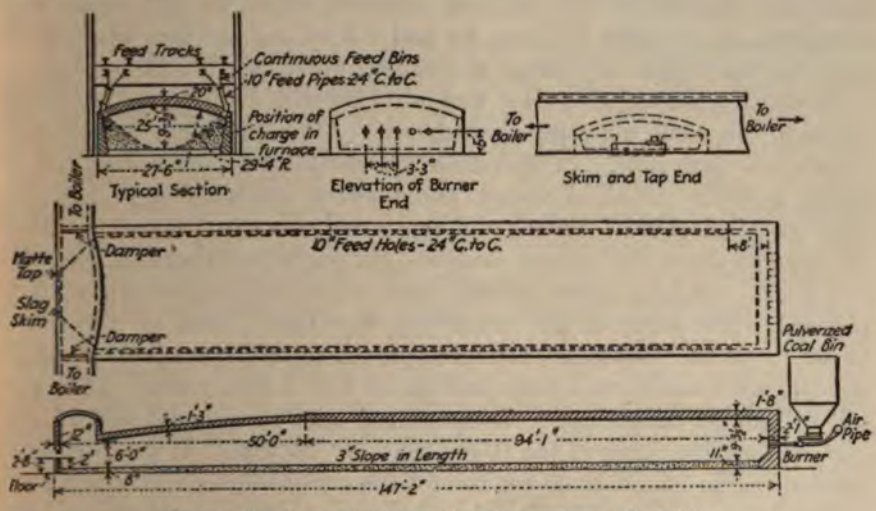
The analysis of furnace gases, taken at the center of the furnace, averages CO_2 15.3 per cent., CO *nil* and O_2 3.0 per cent. The furnace temperatures at 40 ft. from the fire end are 1307° C. and at the flue end 915° C.[1]

• *Large Reverberatory Furnace.*[2]—At the Washoe Plant, Anaconda,

[1] Compare this with the temperature of 922° C. as found at Copper Cliff. The formation temperature of slag is 1100 to 1150° C. At Garfield, in their early experience, trouble arose from the slag crusting over at the furnace front. We can but think that this does not at present occur, due to the rapid formation and removal of the slag; and that the slag formation is exothermic. At Anaconda, burning Diamondville coal on a grate with natural draft, the gas temperatures were: just beyond the bridge 1550° C., and at the front end 1170° C. The actual temperature of the slag is 1170°, its formation temperature 1110° and its freezing temperature 1000° C. (*Bull. Am. Inst. Min. Eng.*, Aug., 1914, p. 1861.)

[2] *Eng. Min. Jour.*, 98, 725; *Bull. Am. Inst. Min. Eng.*, Jan., 1915, p. 81.

Mont., a 144 by 25-ft. furnace is building for coal-dust firing, as shown in the subjoined figures. Figs. 7–11 show typical section and transverse views of the fire end and front end and a plan and a longitudinal section of the furnace. Fig. 12 is a longitudinal section showing the position of



FIGS. 7–11.—Anaconda reverberatory furnace for coal-dust firing.

the charge and the tap-holes. It is 9 ft. 3½ in. high above the hearth at the fire end, and for 50 ft. at the front end slopes gradually to 6 ft. at the flue. The bottom slopes 3 in. to the front, where matte and slag are both removed. The skimming plate is 24 in. above the matte tap-hole. As shown in the typical section, the charge is fed from feed-bins through 10-in. feed-pipes at both sides of the furnace, forming a natural

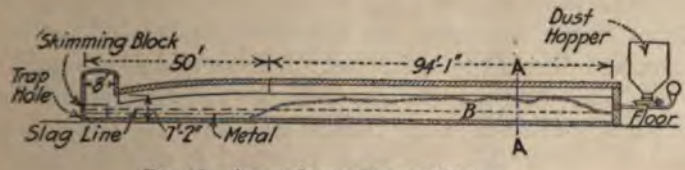


FIG. 12.—Anaconda reverberatory furnace.

slope and incidentally protecting the furnace walls so that fettling is not there needed. The charge is thus spread out to the action of the flame. The output of this furnace is expected to exceed 800 tons daily on a probable consumption of 13 per cent. of pulverized Diamondville coal.

Converters and Converting

Selective Converting.[1]—At the O. K. mine in Australia selective converting is practised to produce two grades of blister copper: one of a grade that would pay to refine electrolytically, the other comparatively free from gold and silver. In ordinary practice, where all the matte was converted, it averaged 0.22 oz. Au and 6.2 oz. Ag per ton, too low in those metals to pay the charge of refining, which was $13.32 per ton.

For this work the converter was provided with two 1½-in. tap-holes through the shell opposite the tuyères. After plugging, a bar was driven into each hole. In operation, the matte of 38 per cent. Cu was blown to white metal, skimmed, and blowing continued 8 to 12 min. with the formation of "bottoms;" the vessel was then turned to bring the tuyères above the molten contents, the bar was withdrawn, and the "bottoms" run into blister moulds, until white metal began to show, then plugged. The white metal remaining was then blown to "ordinary blister." If the "bottoms" produced proved to be too small in quantity the converter was turned back and blown 2 to 5 min. more. This was called "double bottoming." Some 50 per cent. of the gold and 15 per cent. of the silver entered the 10 per cent. of "bottoms" at a cost of production not to exceed $5.00 per ton for the enriched product, which contained 2.47 oz. Au and 17.42 oz. Ag per ton, and which would not pay the refining expense of $13.75 per ton.

The Magnetite Lining.—A. E. Wheeler and M. W. Krejci, in U. S. Patent No. 1,068,470, claimed the process for the formation of a magnetite lining on basic-lined converters.

The newly lined shell is heated gradually to a bright-red heat and charged with liquid matte of say 35 per cent. copper. This is blown for 10 to 15 min. with the addition of cold matte to keep down the heat. Alternate blowing and additions of cold matte are continued until the charge is blown to white metal, but no additions of siliceous ore are made. The interior of the converter has now been coated by the magnetite (Fe_3O_4), formed during the operation. A fresh charge of liquid matte is put in, this time with a little less than the requisite amount of silica, and blowing is continued in the regular way until the brick lining is entirely coated. After this, the silica required to flux the iron is used. Should the coating become too thick, silica and temperature can be increased and a portion of the coating removed.[2]

[1] *Eng. Min. Jour.*, 97, 357.

[2] E. P. Matthewson states that the main thing in basic converting is to keep the temperature within bounds. If overheated, even a little, for half an hour, the lining may be ruined. It is easy to regulate the temperature if the molten mass is large, an argument in favor of extra large converters. However, but few plants can keep a 20-ft. converter constantly in operation, though this size is superior to the 12-ft. one in easy handling and temperature control. (*Bull. Am. Inst. Min. Eng.*, Dec., 1914 2826.)

Various authorities give the melting point of magnetite at 1527 to 1538° C., whereas the ordinary working temperature of the converter rarely exceeds 1200° C.

The inventors think the method applicable to linings other than basic ones, and that basic linings may be made of cheaper materials than magnesite bricks.

Flue Dust for Converter Lining.[1]—L. O. Howard found by a series of tests at the Old Dominion Smelting Works, Globe, Ariz., when using an acid-lined converter, that 18 to 22 per cent. of flue dust could be used in the lining mixture without curtailing production.

Settling Converter Slag.[2]—J. W. James describes his method of cleaning slags of 1.5 to 2.0 per cent. Cu, made near the stage of white metal. The slag, still fluid, was poured into the reverberatory furnace, and a little iron pyrite was added. The slag was reduced in a few minutes to 0.35 to 0.45 per cent. Cu. It might be cleaned in the settler in the same way.

Patentability of the Magnetite Lining.[3]—J. W. James questions the patent claims of Pierce and Smith for a basic lining, and of Wheeler and Krejci for monolithic magnetite linings for basic converters, and mentions Baggaley's patents as having already covered the ground. He shows that it is necessary, both in acid and in basic converting, to make additions or to "dope" the charge with cold matte, cold converter cleanings, and cold scrap to keep the heat from rising so as to attack the lining. It was found as the result of experience that silica should be added in less quantity than the theoretical amount.

In Cerro de Pasco, in 1905, using a basic lining, the charge worked so hot that it was found necessary to give silica in short supply, and to add scrap made by the acid converters, in order to keep down the heat which would otherwise destroy the lining.

Converter Output.[4]—The output of the 20-ft. upright converter at Great Falls, Mont., in February and March, 1914, averaged daily 92.2 tons of copper upon a 35.1 per cent. copper matte, and using 71.3 tons of siliceous flux. At the same time there was oxidized and eliminated 181 tons of iron and sulphur. Considering actual operating time, the output was 108.9 tons or a maximum of 114.5 tons of copper, this when converting a 38 to 39 per cent. copper matte.

Converting Matte.[5]—J. B. Herreshoff in this patent adds the silica toward the end of the blow. With the final slag it forms a hot sintered crust, and from beneath it is poured the white metal. Another charge

[1] *Eng. Min. Jour.*, **97**, 1104.
[2] *Eng. Min. Jour.*, **97**, 1114.
[3] *Eng. Min. Jour.*, **97**, 431.
[4] *Bull. Am. Inst. Min. Eng.*, Feb., 1914; *Eng. Min. Jour.*, **97**, 1247.
[5] U. S. Pat. §1,103,925.

of matte is added and blowing is continued, the matte reacting on the siliceous crust. In this way the silica can be added all at once. For controlling temperature while blowing he admits steam, preferably superheated, together with the air.

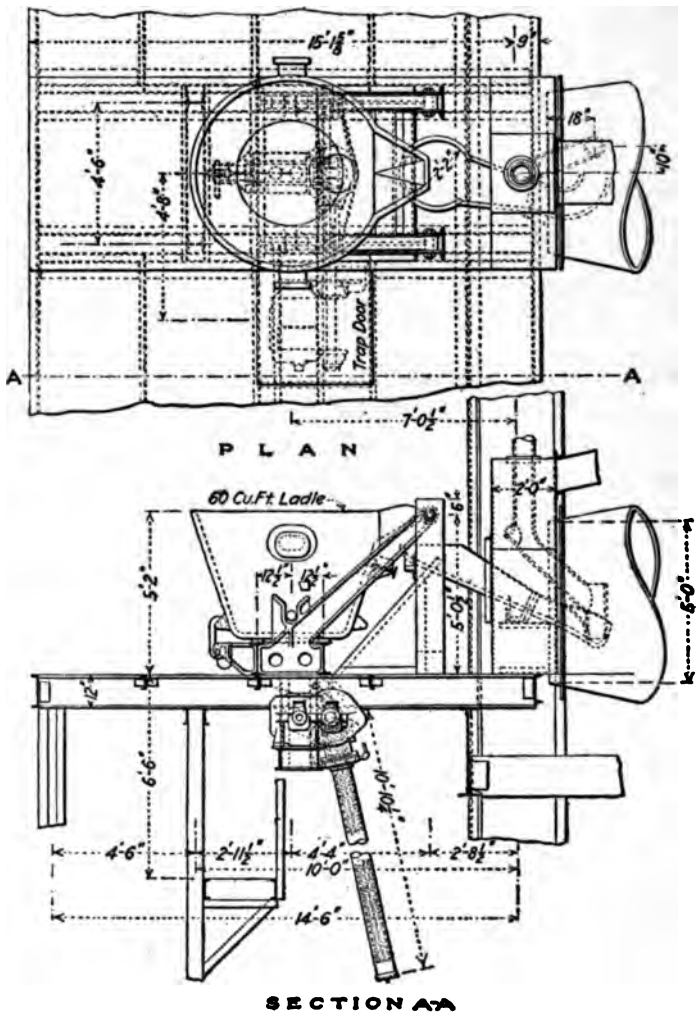


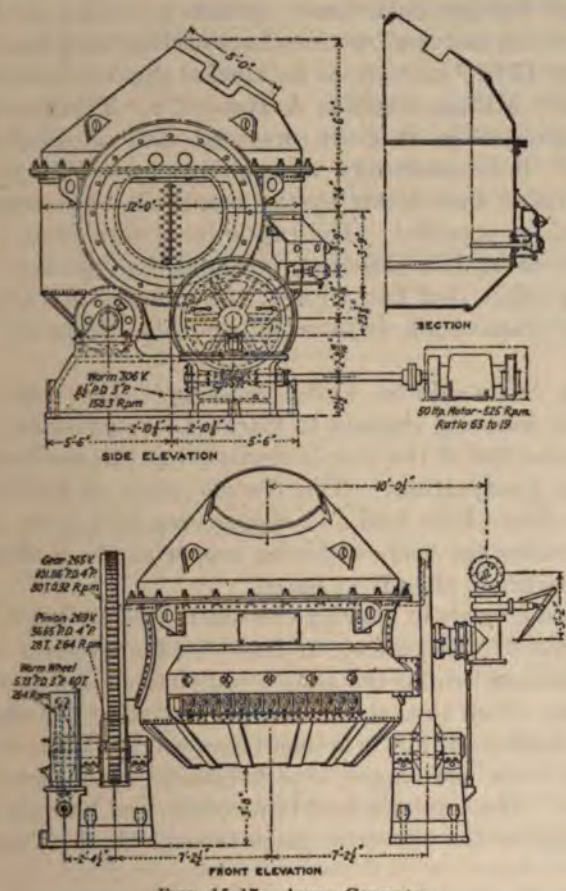
FIG. 13 and 14.—Ladle-tilting apparatus.

Apparatus for Pouring Matte or Slag.[1]—At the works of the Arizona Copper Company the ladle-tilting apparatus is used, of which we give a plan and elevation in Figs. 13 and 14. The traveling crane of the

[1] *Eng. Min. Jour.*, 98, 11.

converter house places the ladle in position in a cradle, hinged to turn the ladle about the pouring lip as a fixed point. The cradle is revolved by a hydraulic ram. In this case the arrangement is used for pouring slag into an agglomerating cone.

Copper-casting Machine.[1]—An endless chain, straight line, copper-casting machine is used at the works of the Arizona Copper Company, Clifton, Ariz.



FIGS. 15–17.—Anyox Converter.

The ladle of copper to be poured is set in a tilting cradle, as shown in Figs. 13 and 14. A jib-crane, 1½ tons capacity, near the pouring end, serves to replace moulds and aid in repairs. There are 40 moulds mounted on roller chain carriers. Spray pipes cool the copper. To eject the cakes there is a countersunk pin at the bottom of each mould. At the discharge

[1] *Eng. Min. Jour.*, **97**, 857.

end the pin is pushed up by a roller on the discharge sprocket shaft, so that the ingot is loosened and falls into the water-bosh.

A lime-water spray nozzle sprays the returning moulds. The bosh conveyor consists of roller chain carriers with crossbars every 4 ft. The crossbars drag the ingots up the incline, and they fall on the loading platform. From this platform they are picked by a radial crane equipped with an I-beam trolley and air-hoist having a 7-in. cylinder.

Twelve-foot Upright Basic-lined Converters.[1]—Fig. 17 shows a side and front elevation and a half section of one of three basic-lined converters, 12 ft. diam. by 17 ft. 7 in. high, as installed at the Anyox Smeltery of the Granby Consol. Mining, Smelting & Power Co. The converter has 13 individual tuyères 2 in. in diam. provided with the Shelby improved tuyère valve. It is electrically worm-driven by a 50-h.p. motor. To remove the collar that forms at the mouth in basic-converting, the recesses are there provided. The cap is lined with brick to the lower edge of the mouth, then plastered, including the recesses, to the top. To remove a collar that has formed, the recesses are broken with a hammer, the crane hook is inserted, and the weakened collar torn loose.

Converting at the Mason Valley Smeltery.[2]—The matte from this Nevada plant, formerly shipped to Garfield for conversion into blister copper, since the first of the year is converted at this smeltery.

Converting Leady Matte.[3]—The Tooele plant of the International Smelting Co. treats both lead and copper ores, and hence can adopt a method of treating the lead-containing copper matte, making use of its converter department already at hand.

The method consists in blowing this matte (received molten from the lead blast-furnace fore-hearths) in basic-lined converters without the addition of siliceous ore, to the almost complete elimination of the contained lead, by which time the matte has arrived at the stage of white metal. This high-grade matte is then transferred to a converter treating copper matte from the copper reverberatories, and there finished to blister copper. The resultant lead-fume of the first blowing is recovered by the filtration of the converter gases through woolen fume-bags in a bag-house.

In ordinary first-stage blowing, with free additions of silica, much slag is formed and the lead enters it, but little being volatilized. This large quantity of slag must then be sent back to the blast furnaces to recover the lead. When silica is not added, a heavy iron slag is formed and the lead does not enter it, being volatilized. Now, not only is SO_2 evolved

[1] *Eng. Min. Jour.*, 97, 1150; *Can. Govt. Mines Report*, 1914; *Can. Min. Jour.*, Nov. 1, 1914, p. 706.
[2] *Met. Chem. Eng.*, 12, 77.
[3] *Bull. Am. Inst. Min. Eng.*, July, 1914, p. 1751; Private Notes.

but SO_3 also, the latter, if free, rapidly corroding the filter-bags. However, in presence of lead oxide and of zinc oxide (also volatilized) the SO_3 is neutralized. At the stage of white metal these oxides are nearly gone, and hence must be transferred to the copper converter which blows directly to the chimney. Also, the purpose of the transfer is to reduce the copper oxide formed, due to the necessary overblowing of the lead matte charge, and to utilize, as far as possible, the value of the heavy iron slag for the fluxing of dry siliceous ores. The final slag from the copper converters is transferred to the reverberatory furnace.

The time of the first blow, if a charge of 10 tons, is about 2 hr., frequent punching being necessary. Fume is at first evolved in dense clouds, this gradually diminishing to the end, by which time the charge contains 1 to 1.5 per cent. lead and has been reduced one-third in weight. The accompanying table gives the details of the blowing in both stages:

TABLE I.—1914—CONVERTING LEAD MATTE WITHOUT THE ADDITION OF SILICEOUS FLUXING ORES TO LEAD-MATTE CHARGE

	Pb, Per Cent.	Cu, Per Cent.	Ag, Oz. Ton.	SiO_2, Per Cent.	Fe, Per Cent.	CaO, Per Cent.	S, Per Cent.	Zn, Per Cent.
Lead Elimination Blow:								
Lead matte	15.0	9.05	20.3	.....	37.9	.....	23.0	5.4
Transfer slag to copper converter	1.4	.....	.....	1.7	59.1	.....	1.8	4.0
Bag-house fumes	64.2	0.37	5.7	0.2	0.4	.....	6.00	10.4
Copper Converter Blow:								
Copper matte	.....	22.2	21.8	.....	41.7	.....	26.6	.....
Siliceous ore	3.4	0.3	17.1	75.1	7.4	3.0	0.8	.....
Converter slag	2.3	1.79	1.6	23.4	48.8	1.5	1.2	2.9

SMELTERIES

Garfield Smeltery.[1]—This has been described in MINERAL INDUSTRY, **15,** 280; **16,** 352; **17,** 240, 275, and its operation in Vol. **19,** 181, 188. We note the following improvements:

There are smelted daily with other ore 1500 tons of concentrates, 800 tons limerock, 200 tons coke. For the reverberatories 1300 barrels of fuel oil are used. For oil powdered coal is being rapidly substituted.

The roasting department now contains sixteen six-hearth MacDougall roasters, 18 ft. diam.; fourteen six-hearth MacDougall roasters 19½ ft. diam.; four Herreshoff seven-hearth roasters 19½ ft. diam. These have a united capacity of 2400 tons.

The 42 in. by 20 ft. blast furnaces have oval fore-hearths of 25 by 15 ft. dimensions and smelt 700 tons each daily. The air consumption is 21,000 cu. ft. per furnace per min. The new blast furnace dust-chamber, of 920 sq. ft. sectional area, is 300 ft. long and contains two 35-ft. and one

[1] *Salt Lake Min. Rev.*, **16,** 14.

10-ft. section hung with Rösing wires at 1⅝-in. intervals. These are shaken mechanically.

The reverberatory building contains six furnaces. Four are 19 ft. wide by 112 ft. long, one is 20½ ft. wide by 112 ft. long, and one is 20½ ft. wide by 120 ft. long, all inside measurements. Five are fired with oil, one with pulverized coal. These furnaces have a nominal capacity of 400 tons each daily. Approximately 1200 tons of slag is skimmed daily. A narrow panel gives space for a coal-car track by which the coal hopper at the fire end of the reverberatory is filled. The charges of roasted ore are trammed to three series of hoppers and are dropped into the furnaces as needed. A sunken way toward the south side gives room for the entrance of the slag-cars which take the slag from the front end of the furnaces.

In the bullion building two Walker casting machines are now used, served from a revolving pouring cylinder that will hold 25 tons.

The Great Cobre Smeltery.[1]—This was described in MINERAL INDUSTRY, **21**, 254. We add these particulars:

Three out of four of the blast furnaces operate continually, the fourth being held in reserve. The matte tap-jacket is of phosphor-bronze and is fitted with a brick-lined spout. The closed furnace top is of steel and of brick to 16 ft. above the charge-floor. Eighteen-foot circular forehearths are now employed, one at each end of a furnace.

The capacity of the plant is given at 1500 tons daily.

Smelting Copper-Nickel Ores at Sudbury.[2]—Dr. H. P. Coleman describes the treatment of the Sudbury ores consisting of pentlandite (2FeS.NiS), chalcopyrite ($Cu_2S.Fe_2S_3$), and pyrrhotite (Fe_7S_8), intimately mingled in a rock gangue.

Part of the ores are heap-roasted and smelted with ores lower in sulphur in the blast furnace to produce a standard matte, then converted to a white metal of 75 to 80 per cent. nickel and copper. This high-grade matte is elsewhere refined.

The roasting ore is burned in heaps of 2000 to 3000 tons, which need 3 to 4 months for completion, yielding a sintered product of 10 to 11 per cent. sulphur. It is loaded into 50-ton railroad cars by steam shovel, and sent to the ore-bins at the blast furnace.

From the ore-bins the charge is drawn off into a train of eight or nine side-dumping cars of 3000 lb. capacity. Three cars hold 1500 lb. of coke, being 10 to 12 per cent. of the charge; the next three carry 9000 to 10,000 lb. of roasted ore, the seventh car has 2000 to 3000 lb. of Crean Hill ore of 12 to 14 per cent. sulphur, or if the main ore is well roasted, the

[1] *Min. Eng. World*, **40**, 547.
[2] *Monograph*, Dept. of Mines, Ottawa, Can.

same amount of Creighton sulphide ore. In the remaining cars is furnace scrap and quartz ore, this varying up to 2000 lb. according to the needs for silica on the charge. Should the furnaces have fine ore or siliceous accretions in the shaft, limestone may be substituted for siliceous ore for a few charges. In charging, the coke is first put in, then the ore and fluxes, and finally the furnace scrap.

The blast is normally 24,000 cu. ft. per min. at a pressure of 25 to 35 oz. The five blast furnaces smelt 40,000 to 45,000 tons per month.

Basic-lined converters of the Pierce-Smith type, 37 ft. long by 10 ft. diam., carried on four tread-rings 12 ft. diam., have been adopted in place of the acid-lined ones formerly used. The new converters are 33 ft. long inside the lining, the bottom is 24 in., the tuyère side 18 in. (around the tuyères 24 in.), the front 15 in., the top 12 in. thick. There are 44 tuyères 1¼ in. diam., but none opposite the mouth where the gases escape. Two openings, opposite and above the tuyères, are for pouring matte and slag.

The converter takes an initial charge of 60 tons of matte, to which is added 6 tons of dry quartz rock; the blast is then turned on. The first slag is skimmed in 30 to 45 min., at which time 5 to 6 tons of matte are added. As the converter is turned up after skimming, 3 tons of dried quartz rock is added, and blowing is resumed. Blowing and additions of matte and quartz are kept up until 70 to 80 tons of white metal of 75 to 80 per cent. has been made, when this matte is poured into moulds. This may require 300 to 400 tons of furnace matte, and take 30 to 50 hr. of blowing time.

To work up a large accumulation of fluedust and fine ore that could not be satisfactorily briquetted, and so could not be sent back to the blast furnaces, reverberatory furnaces elsewhere described were put in in 1911.

Wallaroo & Moonta Smeltery.[1]—Some 260 tons weekly of the lump ore is roasted in stalls, the hot ore resting on bars that are turned every 24 hr. Two-thirds of the sulphur is thus removed. The SO_2 gas thus evolved goes to sulphuric-acid-making chambers which produce 120 tons of chamber-acid weekly. Zinc ore is roasted by the Huntington-Heberlein process in 6-ton pots, eliminating four-fifths of the sulphur.

Two furnaces 48 by 120 in. smelt a charge consisting of roast ore, raw mine ore, limestone and converter slag, using 9 per cent. of coke. The matte contains 40 to 45 per cent. Cu, the slag 0.4 per cent. Cu.

Furnace matte is stored in a 40-ton capacity reverberatory furnace for converter use. From 25 to 40 tons of ore is fed weekly into the fore-hearth. The slag from the fore-hearth is granulated with sea-water. The granulated slag is used for mine filling.

There are two stands of converters in a converter house 200 ft. long

[1] Company Report, 1914; MINERAL INDUSTRY, 18, 221.

and having a crane of 48-ft. span, 38 ft. above the floor. The matte is handled in 6-ton matte ladles. The converter slag is returned to the blast furnace. The converters are acid lined, yielding as much as 33 tons of blister on one lining. Selective converting is performed for the recovery of "bottoms" which in best proportion would be 12 to 14 per cent. of the total copper produced.

At the refinery the blister copper is melted with electrolytic copper produced from the "bottoms" copper and the purest precipitate from the cementation tanks, and the copper refined and cast into market shapes.

Impure ore and slags are run periodically in a blast furnace, the resultant matte being smelted with refinery slag in a reverberatory furnace. In this furnace the copper "bottoms" are added, the copper is poled, then cast into anodes of 99 per cent. Cu for electrolysis.

The gold and silver slime at the refinery, on removal from the tanks, is boiled with sulphuric acid to remove the copper, filtered and treated with lead in a cupel furnace to produce dore bars, which are finally parted to recover the silver and gold separately.

Trail (British Columbia) Smeltery.[1]—Ore is carried in stock in sloping-bottom storage-bins, beneath which run tunnels for cars by which the ore is later drawn off, thus saving shoveling. The ore is brought by conveying belt to these bins and distributed from end to end by trippers.[2] Three new furnaces 42 in. by 35 ft. have been erected, each of 450 tons (?) capacity. These have arched tops and a flat flue, thus eliminating the usual goose-neck off-take and permitting the use of an overhead traveling crane on each furnace floor. The feed-water pipes are controlled from the tapping floor, and the jacket discharge is arranged to afford easy inspection. The furnaces use the Hodges charge car (MINERAL INDUSTRY, 19, 206).

For roasting copper concentrate the Dwight-Lloyd sintering machines are used, these supplanting the Huntington-Heberlein pots.

Blast is delivered by six blowers to the furnaces at 32 to 34 oz. pressure. A No. 11 Root blower of 400 cu. ft. per rev. has been added. This is driven by two 300-hp. induction motors.

The ore treated is chiefly from the company mines at Rossland and gives by analysis Fe 17 per cent., SiO_2 44, CaO 5.5, Al_2O_3 15.5, S 8, MgO 3.5 per cent. This ore is smelted with 30 per cent. limestone and 16 per cent. of Crow's Nest coke.

Arizona Smeltery of the International Smelting & Refining Co.[3]—This is a plant of a subsidiary company of the Anaconda Copper Mining Co.

[1] *Met. Chem. Eng.*, 11, 562.

[2] At the International plant, Tooele, a cross conveying-belt on a temporary frame and running at right angles to the main belt served to distribute ore to several stock piles outside the storage-bin building.

[3] *Eng. Min. Jour.*, 98, 384.

t is connected to the Inspiration and Miami Copper Company's mills, which furnish it concentrates under long-term contracts, over a 1-mile railroad having twenty-four 60-ton cars. The plant has a capacity of 900 tons daily. It comprises steel receiving bins of 1000 tons capacity, sampling works, three 3000-ton steel feed-bins, six 22-ft. drying (roasting?) furnaces, three reverberatories with waste-heat Stirling boilers, one steel stack 300 ft. high by 22 ft. diam., six 12-ft. upright converters capable of producing 250 tons of copper daily. The works is expected to be in operation early in 1915.

The Old Dominion Smeltery.[1]—This treats in blast furnaces ores and concentrate from the Old Dominion and United Verde mines. There are three blast furnaces 44 in. by 16½ ft., and two 44 in. by 19 ft. at the tuyère level, and in them is treated material better suited to reverberatory smelting.

Ore and concentrate, stored in a row of receiving bins, is drawn into weighing hoppers. The charge-train being set, the charge is spouted into side-dump cars of 44 cu. ft. capacity, together with coke, amounting to 12 per cent. of the charge. Some 70 per cent. of the charge is quartz ore, containing Cu 8 per cent., SiO_2 30, Fe 24, S 4 per cent.; the rest of the charge is concentrates (Cu 9 per cent., SiO_2 18, Fe 30, S 28 per cent.) and sufficient iron ore (Cu 2 per cent., SiO_2 17, Fe 43.7) to make a slag of the composition Cu 0.42, SiO_2 37.6, Fe 31, CaO 7 per cent.; and a matte containing Cu 43 per cent., with Au 0.1 oz. and Ag 5.5 oz. per ton. The matte-fall is 12 per cent.

About 300 tons daily is the output per furnace on a blast-pressure of 22 oz. Some 60 tons of flue dust are made, and this, after briquetting, is returned to the furnaces. Converter slag is also fed. At the settler, the matte-tap is of copper cast around two magnesite bricks, and cut at their junction to form a tap-hole between them. This lasts upward of 2 weeks.[2] The elliptical settlers, placed between the furnaces, will serve either, if necessary. The steel shell is lined with magnesite brick and fire-brick.

There are three stands of converters, two horizontal ones, 84 by 125 in., that may be used in an emergency. Practically all the matte is treated in the third, a 12-ft. Great Falls upright converter. In 1913 one of the horizontal converters, on one basic lining, produced in 7 months 7250 tons of blister copper, with an average blast-pressure of 13.2 lb., the actual blowing time being 4 hr. and the copper per blow 11 tons. The largest daily run was 66.4 tons of copper from 50 per cent. matte, and for 3 days 60 tons daily from 47 per cent. matte. The wear on

[1] *Eng. Min. Jour.*, **97**, 1138.
[2] At Douglas, chrome brick is used.

the lining was 1.65 inches per one million pounds of copper. The corrosion was greater along a belt 22 in. above the tuyères where, at the end of the campaign, but 1 in. of lining was left. The upright converter has made as high as 70 tons of copper, and for a month averaged 57 tons daily from 43 per cent. matte. In starting an upright converter, matte is charged and blown without the use of silica, with the production of magnetite. This is made to form a coating on the brick of as much as 5 or 6 in., tilting the converter to aid in the operation. The converter bottom is 10 in. below the tuyères, but 15 in. is considered better. The blast is carried at 12.5 lb., and 205,000 cu. ft. of air is used per ton of blister copper produced from 43 per cent. matte. The blister, cast in ingots of 325 lb., runs Cu 99.16 per cent., with Au 0.24 oz. and Ag 13.0 oz. per ton. The converter slag contains Cu 3 per cent., SiO_2 22, Al_2O_3 1.3 per cent. The siliceous ore used for fluxing carried Cu 5 per cent., SiO_2 75, Fe 5.5 per cent.

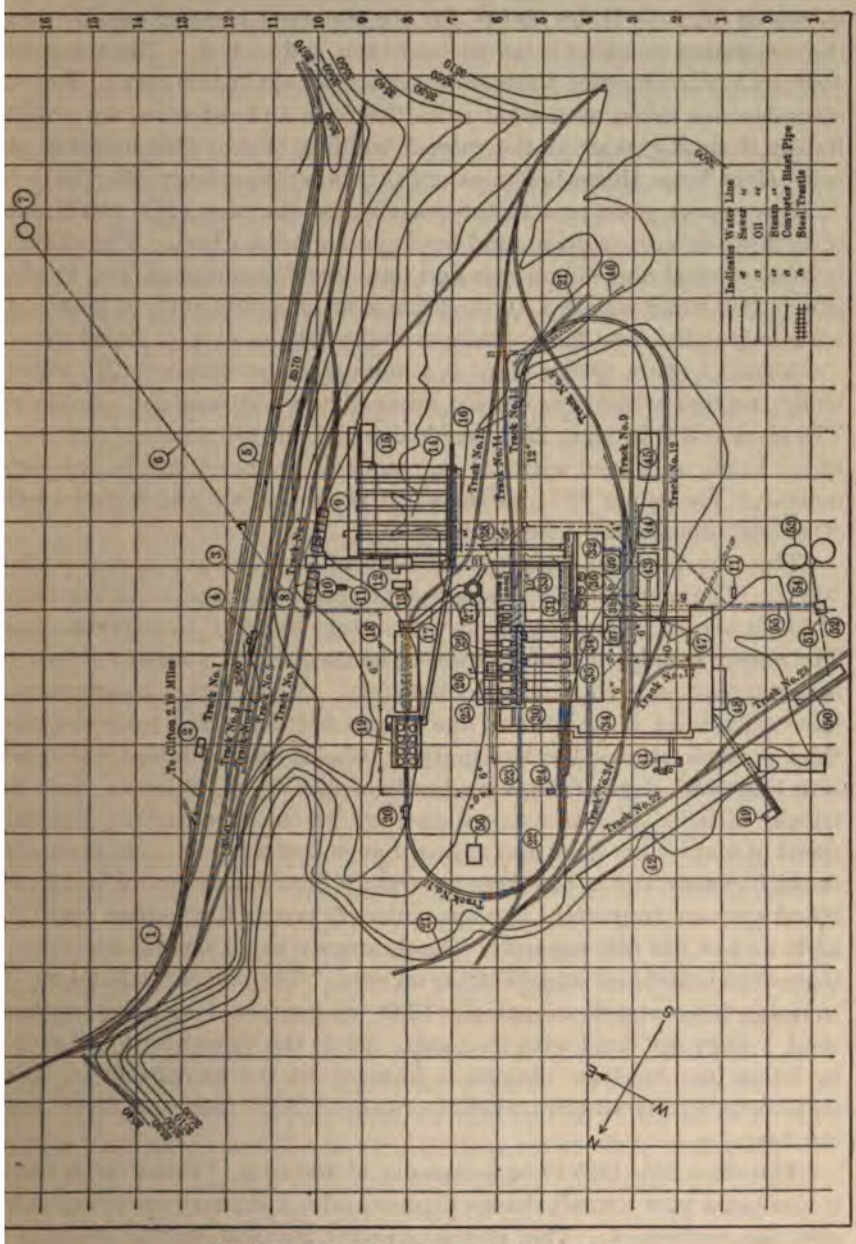
To save time, and to release the converter for a new blow, the copper is poured at once into the crane ladle, then transferred to a pouring ladle which can do the work of moulding into ingots at leisure.

Arizona Copper Co. Smeltery.[1]—This is situated 2 miles south of Clifton, Arizona, and is a reverberatory plant only. The equipment consists of eight Herreshoff multiple-deck roasters, three reverberatory furnaces and three stands of upright basic-lined converters.

Fig. 18 is a general plan of the smeltery. Ore and concentrates are delivered by overhead track No. 7 to the receiving bins (8) which are in two sections, 1000 tons for ore, 1500 tons for concentrates. The ore is drawn from the bins upon a 30-in. conveying belt, delivering to the coarse crushing plant set between the bin sections, then by another belt to the sampling mill (12). Here it is successively crushed by 12 by 48-in. rolls, 16 by 42-in. rolls and 12 by 24-in. rolls, using a Snyder sampler after each reduction. The concentrates are separately sampled, using Vezin samplers. The samples are finished in an adjoining building (13).

The crushed ores are delivered by conveying belts to bunker-bins (16). These bins hold 4000 tons, and store ore for the silica bins (32) at the south end of the converter building (35). Some of the crushed ore and the concentrates, after sampling, are taken by conveying belts to the Messiter-system beds (14) (see MINERAL INDUSTRY, **15**, 249; **16**, 356; **18**, 191; **19**, 188; **21**, 228; **22**, 188). The ore and concentrates (with additions of crushed limestone) are distributed uniformly to the bedding floor beneath by means of a traveling ore-bedding tripper. Upon this floor stands the reclaiming machine, 62 ft. long, by which the bedded ore is sent to the

[1] MINERAL INDUSTRY, **20**, 227; *Eng. Min. Jour.*, **97**, 1279; **98**, 11; *Bull. Am. Inst. Min. Eng.*, July, 1914, p. 1497; *Min. Press*, **110**, 9.


Indicates Water Line
" Steam "
" Oil
" Slimp "
" " Converter Blast Pipe
" " Steel Trestle
To Clifton & Ry Affiliations
Track No. 1
Track No. 2
Track No. 3
Track No. 4
Track No. 5
Track No. 6
Track No. 7
Track No. 8
Track No. 9
Track No. 10
Track No. 11
Track No. 12
Track No. 13
Track No.

roasters. At the end of the beds, shown adjoining (9) of Fig. 18, is the trench or pit 21½ ft. by 300 ft. for the reclaimer transfer car, by which the reclaiming machine is transferred from bed to bed. The three beds 55 ft. by 172 ft. effective dimensions, each will hold 12,000 tons. The concentrates are taken as needed from the beds and delivered by trippers to any desired roaster at the roaster building (19). This building contains eight large Herreshoff roasters (MINERAL INDUSTRY, 22, 193).

The roaster gases pass to the roaster dust-chamber (18), 140 ft. long, of 1325 sq. ft. cross-section, and having a hopper bottom. The chamber is built of steel and hollow tile and has a roof covering of No. 11 sheet iron. It is hung with No. 10 steel wires, totaling 280 miles in length, the wires suspended from horizontally stretched chains at 4-in. intervals.

A good feature of this plant is a main stack or chimney (27) set centrally, around which are closely grouped the furnaces and converters. The stack is 300 ft. high, 22 ft. inside diam. at the top, made of perforated radial brick, and lined with a 4-in. course of fire-brick laid in acid-proof mortar. The upper 75 ft. of the stack is pointed outside with a mortar of sodium silicate and asbestos fiber.

The reverberatory furnaces (30) are of unusual width, being 22 by 100 ft. The reverberatory gases pass to seven waste-heat Stirling boilers of 712 h.p. each, thence by the reverberatory flue (26) to the main stack. The boilers supply steam for power to be used at the company mines and concentrator, as well as for the smeltery. Two of the reverberatories have silica-brick bottoms, and one a sand bottom. The roofs are 20 in. thick. Each furnace has two matte tap-holes by which matte is tapped into cast-steel slag-cars, having bowls of 225 cu. ft. capacity, and electrically tilted. All these are drawn by 18-ton locomotives, having a speed of 6 miles per hour and a draw-bar pull of 8000 lb. Oil is supplied to the furnaces, and to the three separately fired boilers by six Wilgus No. 16 oil systems from eight service tanks (28) each 10 ft. diam. by 12 ft. high, and of 163 bbl. capacity. Each furnace being separately supplied, there is an individual control of the oil used. The converter building (35) contains three stands of upright 12-ft. converters, two being normally used. They are lined with magnesite brick, the dished bottom being 15 in. below the tuyères. Matte is brought to the converters in 20-ton ladles handled by 40-ton traveling cranes of 55-ft. span and 50 ft. above the floor.

The silica bins (32) have a capacity of 100 tons. From them the ore is measured into a small charge hopper and fed through swinging chutes into the converters. This is a convenient method, saving waiting for the cranes.

The converter dust-chamber at (31) is hung with No. 10 steel wires

(56 miles in all) from ⅜-in. horizontally stretched steel chains at 4-in. centers. The wires extend into the hoppers.

The converter copper is cast in straight-line casting machines in the casting shed (37). (See description, p. 225, and MINERAL INDUSTRY, **20,** 229.)

We gave, in MINERAL INDUSTRY, **22,** 214, the apparatus as used at the Copper Queen Smeltery, Douglas, Arizona, where flue dust and converter slag are agglomerated. At the works of the Arizona Copper Company, ore crushed to ¼-in. size substitutes flue dust, and there is produced a hot self-fluxing mixture for the furnace. The arrangement of these two agglomerating or clinkering machines is given in Figs. 13 and 14.

From the converter dust-chamber (31) an 8-ft. circular flue leads to the main stack. The converter engines are of the Nordberg type with steam cylinders 22 and 40 in. diam., air cylinders 44 in. diam., all of 42-in. stroke, and have a capacity of 10,000 cu. ft. of air per min. at 12 lb. pressure per sq. in.

The El Paso Smeltery.[1]—The plant of the American Smelting & Refining Co., El Paso, Texas, has installed a copper smelting department for the treatment of Chino concentrates and other custom ores. This installation comprises eight Wedge roasters, three 19 by 100-ft. reverberatories, three basic-lined converters (two of the Pierce-Smith and one of the Great Falls or upright type). Besides these are two older 44 by 144-in. blast furnaces. An interesting feature is the craneless converter house.

The blast furnaces have cast-iron tap-jackets and a water-jacketed spout, trapping the blast at 8½ in., with a blast-pressure of 30 oz. on a smelting column of 10 ft. The flue dust averages 4.5 per cent. of the tonnage. About 11 per cent. coke is used, with an average output of 278 tons daily, or nearly 7 tons per sq. ft. of hearth area. The slag composition is SiO_2 38.2 per cent., FeO 26.6, MnO 0.8, CaO 24.2, ZnO trace, Al_2O_3 8.4, Cu. 0.39 per cent., also Ag 0.1 oz. per ton. The copper on the charge is 7.7 per cent., the sulphur 9.8 per cent. The matte-fall averages 15 per cent., and the grade of the matte was 47.4 per cent. Cu (a satisfactory figure) with a concentration of 6.5 to 1 and with a volatilization of 63 per cent. of the sulphur. The settlers are 14 ft. diam. with a cast-iron tapping-block for the matte. This is received in slag-cars running on a depressed track, then taken while molten by elevated track and tapped into the converters. Recently an auxiliary settler, 12 ft. diam. with a domed roof of silica brick, has been tried. This settler is oil-fired, using 4 bbl. of oil per day. Little matte is caught in this second settler, its chief value being as a storage of slag.

[1] *Eng. Min. Jour.*, **98,** 515.

The Wedge roasters are 22 ft. diam., with three roasting hearths. The sulphur in the concentrates is from 13 to 17 per cent. The furnaces are oil-fired, using an average of about 8 gal. of oil per ton of charge. The calcine varies from 9 to 11 per cent. S. The output is 140 tons per furnace daily. The concentrate is brought by tram-cars which dump into a bucket-elevator, this delivering to the roaster hoppers[1] by means of a 20-in. conveying belt with a movable tripper.

The gases from the Wedge roasters (and also from the blast furnaces) are carried off by a brick flue of 10 by 15 ft. cross-section. This flue later enlarges to 16 by 20 ft. where it has a hopper bottom. One wall of this enlarged flue is common with a flue of 10 by 17½ ft. which belongs to the lead-smelting furnaces of the works. The two flues unite into one about 100 ft. from the main stack. This stack is 14⅔ ft. internal diameter and 225 ft. high. It discharges 300,000 cu. ft. of gases per min. or at the high velocity of 30 ft. per sec., and at a temperature of 132° C.

The three 19 by 100-ft. reverberatories are oil-fired, and smelt 300 tons each daily, though as high as 400 tons has been smelted during one 10-day run. The oil burners receive air at 15 lb. pressure. Secondary air is also admitted above the burners. The matte varies from 40 to 45 per cent. Cu. The slag is removed in 5-ton slag-cars having bowls of 50 cu. ft. The outlet flue is sheathed with asbestos to shield the skimmer when he is tapping slag. This difficulty is overcome at the Hayden plant by carrying the flue high so as to give liberal head room. For fettling, ore averaging SiO_2 70 per cent., Fe 2, S 3, Cu 7 per cent. is used. This is thrown across the furnace through the side doors, but at the bridge is dropped through the roof. The fettling material is disposed, however, to slough off. Seven 400-h.p. waste-heat boilers are used.

The converter department can produce 4000 tons of blister copper per month. The Pierce-Smith converters have lasted to 7000 tons of copper per lining. For them a 1½-in. tuyère is preferred. They are equipped with oil-burners to keep them hot in case of delays. To avoid the formation of converter collars the converter mouths are built up with clay, and the converter runs with but little slop or spilling. Converter air is supplied at 10 to 15 lb. pressure, using 160,000 cu. ft. of air per ton of blister produced. Matte, in 6- to 10-ton hand-tilted ladle-cars, is hauled by a small steam locomotive up a 2 per cent. grade to the upper or charge-floor of the building and is poured into the converters. The silica flux is delivered into the converters in the same way. The converter slag averages SiO_2 23.5 per cent., Fe 50.8, Cu 1.7, and Ag 0.25 oz. per ton. Both slag and blister are received into tilting slag-cars set

[1] The criticism is made that the hoppers receiving the calcine are so small that inconvenience results, owing to the long intervals between reverberatory charges.

on a track running in front of the converter. No overhead traveling crane is used in this installation, so saving its first cost.[1]

Two ladlefuls of blister copper are received from a full converter charge, which is poured in 20 to 30 min. A full ladle, having been set at the endless-chain straight-line casting machine, is raised by a hydraulic cradle 36 in. diam. by 11 ft. long operated under 200 lb. water pressure. The ladle is so lifted in the cradle as to revolve and pour about the line of the tip of its spout, thus kept in the same position. The metal stream is received in a pouring spoon, and flows thence into the cast-iron mounds of the casting machine. The moulds are reinforced by a steel plate on the back. The handling and pouring of the copper is more slowly done than at the Hayden plant where the pouring cylinder is large enough to take several converter charges and crusts less.

Hayden Smeltery.[2]—This plant of the American Smelting & Refining Co. was built in the remarkably short time of 8 months. This haste was due to a contract to smelt the concentrates of the Ray Consolidated Copper Co. Work was conducted both on day and night shifts, and at higher cost than if built normally. The cost is given at $1,600,000.

The Ray concentrates carry Cu 18.5 to 20 per cent., insoluble 28 to 32, Fe 22 to 25, S 25, CaO 1, Al_2O_3 5 to 6 per cent. Much of this is fine and, with the slimes high in silica, tends to form an infusible siliceous coating or blanket upon the reverberatory charge which is difficult to flux.

The concentrates are received in 60-ton gondola cars and when unloading each tenth shovel is reserved for a sample. Fluxes, as limestone and siliceous ore, are crushed and mechanically sampled. The line of receiving bins is 322 ft. long, and takes both fluxes and concentrate, the latter occupying three of the 2000-ton bins.

Three 20-in. belt conveyors transfer materials to the roasters. One runs under the receiving bins, an inclined one runs to the top of the roaster building, and one distributes by aid of a tripper to the roaster hoppers. Separate hoppers receive the limestone or siliceous ore and these can deliver to the lower hearth of the roaster, or directly into the calcine cars. The siliceous flux, needed at the converter plant, and crushed to walnut size, goes for drying to one of the roasters.

The roaster building, 233 by 48 ft., contains three six-hearth McDougall furnaces, 19 ft. 6 in. diam., five branch off-takes from each roaster leading to the main dust flue, and from this flue are pipes leading

[1] It is a question whether this omission of the crane is well advised. The crane is close to its work, and will do other work besides charging and discharging the converters, and is within sight and control of the foreman, whereas at night, in the locomotive-served plant, the ladle may be 800 to 1000 ft. away. In transferring slag from the lower to the feed-floor track at the reverberatory it is necessary to disturb the flux cars at the converters, and these must be later set back.

[2] *Eng. Min. Jour.*, **98**, 553.

down to the calcine hoppers of each roaster, the flue dust there mixing with the calcine. The larger roasters have 35-ton, the smaller 32-ton, feed hoppers, and below, each roaster has four 10-ton calcine hoppers. It is provided with an oil-burner, used intermittently for 15 to 20 min., then perhaps not for 2 or 3 hr., as it is aimed not to reduce the sulphur more than to 12 or 14 per cent. from the original 25 per cent. Three to 4 gal. of oil are used per ton of ore roasted.

Due to careful draft regulation, only 1 per cent. of fluedust is made. This is accomplished by adjusting the dampers so that the last roaster in line barely smokes. The draft averages 0.15 in. of water.

When the furnaces were first operated the wet concentrates tended to bank and slide round on the top hearth, but this was overcome by omitting every second rabble blade, and by having the remainder made longer. When the cast-iron rabbles get worn they are pieced out by bolting to the stub a plate 6 by 8¼ in. The column openings through the second, fourth and sixth hearths were at first provided with covering collars. These have been replaced by curved rabbles on the rabble arms which better stir and spread the ore. This change has increased the daily output from 85 to 100 or even 110 tons.

For use at the reverberatory furnaces the calcines and dried siliceous ore are drawn off into 5½-ton cars which have bottom arc-gates. The steel reverberatory-furnace building, 127 by 160 ft., houses two reverberatory furnaces and their six 350-h.p. waste-heat Stirling water-tube boilers. The foundation of the reverberatory is of concrete, 3½ ft. deep, above which is the 24-in. siliceous bottom. The furnace walls are of silica brick, 34 in. thick, outside of which comes 5 in. of fire-brick. There are three pairs of charge hoppers each of 200 cu. ft. capacity, 6 ft. square and with a cone-valve, fitted to prevent leakage when closed. A fire-brick extension, 12 to 15 in. high, unites the hopper spout with the charge hole. The outlet flue is carried high above the head of the skimmer.[1]

The reverberatory furnaces are oil-fired, and provided with five burners per furnace, though three are ordinarily used. Air is supplied from the converter air-main. The daily capacity per furnace is 350 to 400 tons. A matte of 40 to 42 per cent. Cu is made, the slag running from 43 to 45 per cent. SiO_2, Fe 28 to 30, CaO 7 to 10 per cent. When the latter falls below 7 per cent. the slag losses increase. The limestone, say 1500 lb., is put first into the charge-car which is then filled with the calcine. Two 5½-ton charges are dropped each 30 min. When molten converter slag is to be added, it is preferably done just after charging the

[1] As at Garfield, Utah, and at Greenwood, B. C., when changing pots, the slag is caught in a movable "spoon" swung or tilted into the outflowing stream. This is received into slag-cars of 225 cu. ft. (25 tons) hauled by an 18-ton electric locomotive.

calcine, since a visible reaction then occurs between it and the calcine, and the speed of smelting is increased. Cold converter slag, added in the same way, would often sink, sticking to the bottom and building up. This suggested the idea that it might replace siliceous ore, which was inclined to slough off badly, not sticking to the side but spreading out and blanketing the surface of the molten bath, even forming floaters that were skimmed unmelted. When tried, the reverberatory slag was found to be the best material for fettling. There are no blast furnaces, and this use of the slag avoids bottom-building, and gives an outlet for the use of much cold aluminous slag. The pair of fettling hoppers at the fire end have eight feed pipes dropping the fettling material through holes in the roof, this being accomplished in 15 min. At the first four or five doors at the side are fettling hoppers that permit material to be dropped from the roof. Beyond this the sides are fettled from a movable hopper dropping through openings at the spring of the arch. In the next furnace to be built, both sides will be thus repaired, each movable hopper having multiple openings.

In burning oil the draft is regulated to carry the flame as far as the mid-length of the furnace, *i.e.*, to the sixth door. At the eighth door the draft is 0.2 in., at the throat 0.6 to 0.8 in., at the main flue 1.6 in. of water. Based on a daily output of 350 to 400 tons, the oil consumption per furnace is 12,000 to 13,500 gal. or 0.75 to 0.85 bbl. per ton of ore smelted. The oil is heated by a steam coil at the storage tank, and again by another coil contained in a 12-in. pipe on the way through a 4-in. main to the furnace, attaining a temperature of 85° C., and is then tapped to the individual burners. It is difficult to atomize the oil below 48° C. (120° F.).

The main flue from the waste-heat boilers, 950 ft. long, leads to a 300-ft. stack, 25 ft. diam., set on a hill. This stack is lined with radial bricks, and for 100 ft. with bricks laid in acid-proof mortar. The inside joints near the top and for 40 ft. on the outside are similarly laid.

The converter building, 256 ft. long, contains two Pierce-Smith converters and a 12-ft., upright, Great Falls type converter. The Pierce-Smith converters are 25 ft. 10 in. long by 10 ft. diam. The average of four runs shows an output of 5400 tons of copper on one lining, the best run being 7758 tons per lining. In 22 months' operation these two converters have produced 50,250 tons of copper. Each had 36 tuyères 1¼ in. diam., but this has been changed to 1½ in. diam. The upright converter has 26 tuyères, 1¼ in. diam. A distance of 12 in. from the tuyère line to the bottom is maintained.

The flux for the converters will average 60 to 70 per cent. SiO_2. When blowing a 43 per cent. matte with this flux the converter is inclined

to get cold, but when an 85 to 95 per cent. silica flux is used, the converter gets hot and tends to cut at the tuyères. Flux of from pea to nut size is the best; if much is coarse it tends to form balls that have to be broken up. A converter charge will average 8 tons, needing 2½ tons of flux. The converter slag ranges from 20 to 23 per cent. SiO_2 and from 48 to 53 per cent. Fe.

In the copper-casting house the copper is handled by a pouring cylinder 14 ft. long by 8 ft. diam., holding 50 to 70 tons of the metal. The shell of the cylinder is of ⅝-in. steel, lined with magnesite brick-bats to a little above the slag line, and above with fire-bricks, this lining being preferred to one of silica bricks. A lining will last for 8000 tons of metal. The cylinder is lifted for pouring by an 80-ton stationary electric crane connecting with the cylinder cradle, the cradle so pivoted as to keep the pouring nose of the cylinder practically at the same point. The lid covering the charge openings of the cylinder is raised by a small auxiliary hoist when it is desired to pour in blister copper from any converter. Copper is cast on two shifts out of the three, and in the waiting interval is heated by oil-jets, 400 to 500 gal. being needed daily. Before moulding, the supernatant slag is skimmed through a small door at the end opposite the oil-burner. Copper is cast in a 27-mould Walker casting machine, making 275- to 300-lb. ingots. Two shifts of 9 men each stack, trim and load 110 to 140 tons per day.

The Hayden plant is a model plant, reflecting great credit upon its designers.

The Lampa Smeltery.[1]—This is situated at Santa Lucia, Puno, Peru, 14,250 ft. above sea level, 133 miles from Arequipa. It has a single 36-in. circular blast furnace of 35 tons daily capacity, using 7½ to 10 per cent. of coke which contains 34 per cent. of ash and costs $31.75 per ton. Matte of 40 to 55 per cent. Cu is made. The slag runs SiO_2, 39 per cent.; FeO, 41; CaO, 8; Cu, 0.2 per cent. Some 12 to 15 per cent. of flue-dust is made. Lines of single mine-rails are laid from the ore piled to the furnaces, and wheel-barrows are employed having wheels with concave treads which fit these mono-rails.

The works are run by a 60-h.p. boiler fed with 4 tons daily of llama dung costing $2.50 per ton.

Union Minière du Haut-Katanga.[2]—In 1913 the production of this African property was 7245 tons of blister copper of 95 to 96 per cent. Cu, also 168 tons of 68 per cent. matte, produced by two blast furnaces. Two blocks of 24 ovens each furnish 3000 tons of washed coke per month. The third blast furnace was blown in in December, 1914, and

[1] *Min. Sci. Press*, 109, 553.
[2] *Echo des Mines et de la Métallurgie.* Traylor Engineering & Manufacturing Co., *Min. Press*, 110, 142.

two more are to be erected in 1915. Costs in 1913 were $160 as against $158 per ton of copper in 1914. Production for 1914 was estimated at 12,000 tons, for 1915, 25,000 tons.

The two new blast furnaces are of 44 in. by 20 ft. hearth area, have a 14-in. bosh, and are no doubt the largest black-copper furnaces yet built. The brick-lined crucible is 16 in. deep, and copper is tapped from it through a spout at the long side 5 ft. from the end. Slag is removed from the furnace by a trapped spout at one end and by an ordinary spout at the other. Separation is therefore, as usual, effected inside the furnace. The working height of the ore column may be given

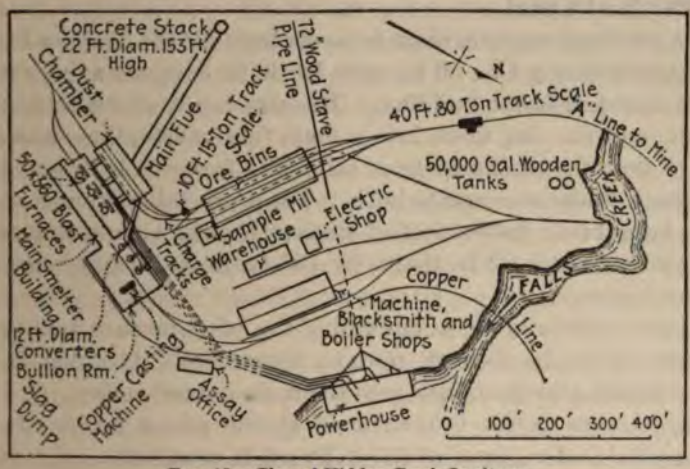


FIG. 19.—Plan of Hidden Creek Smeltery.

as 15 ft. 4 in., with inclined distributing plates to the feed floor 2 ft. 9 in. higher. The height from the slag-floor to the feed-floor is 27 ft. 2¾ in. The crucible is carried on columns, and for removal is raised a little by jack-screws, the columns taken away and the whole lowered upon rollers at the floor-level, so that the crucible base-plate and crucible may be rolled to one side. The closed top is carried 30 ft. above the feed-floor to receive a Giroux hot-air heater. Cold air is brought in by a 36-in. main at one end near the top, and delivered at the other end to the bustle pipe. The furnace has 20 tuyères per side.

Hidden Creek Smeltery.[1]—These new works of the Granby Consolidated Mining, Smelting & Power Co. are situated at Anyox, B. C. Some 8,000,000 tons of 2 per cent. copper ore have been developed at the near-by mines of the company, besides a much larger tonnage of lower grade ore. The works are on the west shore of Granby Bay of Observatory Inlet, just south of Falls Creek, as shown by Fig. 19. The mines

[1] *Eng. Min. Jour.*, 97, 1.

are 9600 ft. north and Anyox, the shipping point, 3000 ft. east, and connected to the works by a 3-ft. electric haulage line with 25-ton locomotives.

Two distinct ore-bodies have been opened, a heavy sulphide, pyrite and chalcopyrite of over 2 per cent. Cu, and one a siliceous sulphide averaging 2 per cent. Cu. The ore from the mines comes in over an 80-ton scale, branching on top of the ore-bins of 8000 tons capacity. From these bins ore, coke and limestone are drawn off on a track 35 ft. below the top of the bins. The coke is secured from Crow's Nest Pass in Southwestern Alberta, the limestone from a quarry 25 miles below Stewart on the Portland Canal.

There are three matting blast furnaces built by the Traylor Engineering & Manufacturing Co., 50 in. wide by 30 ft. long, set axially with the length of the steel-frame building. The slag tap is at the middle of the front side, and the slag flows into a main fore-hearth, then into a guard settler, so that the discharge from adjoining furnaces is received into a granulating launder common to both. The down-takes from the furnaces lead to a large brick dust-chamber, thence through a main flue to a reinforced concrete stack 22 ft. diam. by 153 ft. high, its top being 300 ft. above the furnaces.

The converter building, at one end of the blast-furnace building, contains three 12-ft., basic-lined, upright converters. The flue from the converter hoods also discharges into the main dust-chamber.

Hydro-electric power is developed at the power house, the water being supplied under a head of 400 ft. by a 6-ft. wood-stave pipe from the dam on Falls Creek. The power-house equipment includes two electric generators of 938 kw., two motor generator sets of 300 kw. each, three Connersville blowers of 48,000 cu. ft. of free air per min. at 3 lb. pressure. These blowers are driven by Pelton impulse wheels. For the converters there is a Nordberg blowing engine of 21,500 cu. ft. per min. capacity at a pressure of 16 lb. A Nordberg compressor also supplies 4000 cu. ft. of free air per min. at 100 lb. pressure. Both blowing engine and compressor are driven by Pelton wheels.

A copper track removes the blister copper from the converter building to the wharf at Anyox.

Calumet & Arizona Smeltery.[1]—This plant comprises a crushing and sampling mill, a bedding and conveying system, two 40-ft. blast furnaces for the treatment of coarse ore, four 19 by 100 ft. reverberatories for the fine ore, also six stands of 12-ft. upright converters, and two casting machines for the production of blister copper. Advantage was taken of the presence of the older plant already in operation to build benches

[1] *Eng. Min. Jour.*, 98, 102, 166; Private Notes.

and walls as foundations for the new one, slag being deposited at the rate of 1500 tons per day.

Ore, stored in the receiving bins, is fed through chutes into the feed hoppers of the 30-in. conveyor belts, delivering to two 36 by 24-in. Blake crushers at the end of the bins. From these the coarsely crushed ore goes by two inclined conveying belts to the top of the five-story crushing and sampling mill. The mill, 40 by 84 ft., is run in two independent duplicate sections, and each section has its crushing and its sampling department. Each crushing department contains one 54 by 24-in. Blake crusher, two 20 by 10-in. crushers, one 54 by 24-in. roll and two 14-ft. trommels, where ore can be crushed and screened to any desired size. Each sampling department is equipped with one 20 by 10-in. Blake crusher, one 36 by 12-in. roll, one 24 by 12-in. roll, with Snyder samplers interposed after each crushing, the resultant samples weighing 1.6 lb. per ton of ore sampled.

From the mill the ore goes by conveying belts to a Messiter bedding system, the fine ore to three beds, the coarser to three beds, each bed of 10,000 tons capacity. A bed to hold 500 tons of coke is also provided. Reclaiming machines transfer material from the beds by conveying belts, the coarse ore and coke to the blast-furnace bins, the fine ore to the roaster plant.

A main building, 222 by 460 ft., contains the two blast furnaces, four reverberatories, six converters and a copper-casting department. The blast furnaces are set on a slag block or fill, so that the slag-car can approach on one side and the matte ladle on the other. The bustle pipe is semicircular with the tuyères bolted to the flat lower side, permitting of some variation in their height. The furnace has the usual water jackets below, but the sheet-steel top is double, allowing air circulation, tending to keep the top cool. From this top a goose-neck passes off to the dust-chamber.

The charging system is peculiar. Ore and coke bins are supplied by 24-in. belt-conveyors from the beds. Beneath them and at each side of the furnace is set a charge-car, as long as is the furnace itself and 4 ft. 5 in. wide. The feed chutes are operated by air cylinders. When filled the cars are weighed, then propelled to the furnace doors by means of an electric motor, the furnace door is opened, and the slide at the front of the charge-car is raised, the car contents discharging over the distributing plates into the furnace.

A steel dust-chamber, 60 by 100 ft. and 70 ft. high, provided with baffle-plates and wires, receives the blast-furnace fumes. These fumes then pass through an overhead flue to a brick-lined steel chimney, 305 ft. high and 25 ft. inside diam.

The roaster building contains twelve six-hearth Herreshoff roasters, 21½ ft. diam., each having a capacity of 80 tons of fine ore per day. The roaster fumes pass through a tile and steel dust-chamber, 60 by 140 ft. area by 70 ft. high, provided with baffle plates and wires, to a brick-lined steel stack, 279 ft. high and 20 ft. inside diam.

In the reverberatory department are four coal-fired furnaces, 19 by 100 ft., of regular construction and operation. Each furnace has two 712-h.p. Stirling waste-heat boilers. Contrary to the usual plan, the furnace gases pass in at the top of the boiler, thence by baffles downward through the tubes. Matte is tapped into 20-ton pots, and transferred by a traveling crane to the converters. The slag is skimmed into 25-ton electrically tilted slag-pots mounted on slag-cars. These run on tracks beneath, and just in front of the front end of the furnaces. These reverberatories are built on slag-blocks. For the bottom 4 in. of clay is laid down, and on this comes the sand bottom 21 in. thick.

The converter department contains six stands of 12-ft., upright, basic-lined converters. The main converter aisle is 55 ft. wide and has two 40-ton electric cranes. The converter dust-chamber, 40 by 60 ft. area by 50 ft. high, has a stack 200 ft. high and 16 ft. diam. A balloon flue, 15 ft. diam., just back of the converters, conducts the fumes to the chamber, and this flue collects most of the dust.

The siliceous ore is brought to the bin by a conveying belt. From the bin it is drawn into a traveling charge hopper that can deliver into the swinging chute of any converter. This quite relieves the cranes from this work, and there is no waiting for the siliceous additions.

Furnace Products

The McGregor Skull-breaker.—The skulls or shells, either from a side-dumping slag-pot or from a converter ladle, are delivered into an inclined feed chute falling upon a grating or grizzly having 8-in. square holes. A vertical ram mounted on a transfer carriage can reach any place upon the grating, where it operates to break up the large pieces to a size such that they will pass through the grating upon the conveying belt below.

Removal of Flue Dust by Chain Conveyor.[1]—A balloon flue of the Detroit Copper Mining Co. is fitted with a ⅝-in. endless chain for the removal of the flue dust as it accumulates. The chain, having a speed of 40 ft. per min., is operated 6 hours per day by an electric motor, scraping the dust into a collecting hopper near one end of the flue. There is a tail wheel and tension gear for taking up the slack of the endless chain. The

[1] *Trans. Inst. Min. Met.; Eng. Min. Jour.*, 98, 353.

flue is 27 ft. high by 18 ft. wide, and here the velocity of the gases is reduced to 4 ft. per sec., ensuring effective settling. Twelve tons of dust per day is thus collected.

Copper Plates for Roofing Dust-chambers.[1]—Soluble iron sulphates accumulate on the under side of these plates and corrosion soon destroys them.

Electrical Fume Precipitation.—For details on fume precipitation see the special article later in this volume on "The Smoke Problem in the Mineral Industries", by F. G. Cottrell and Linn Bradley.

Copper and Its Alloys

Electrical Resistivity of Brass.[2]—According to experiments made by E. F. Northrup on a brass of Cu 63 per cent., Zn 34.6, Pb 2.4, with traces of Sn and Fe, the resistivity began at 6.957 microhms at 20° C. and increased regularly so that near the melting point (850° C.) it had become 15.5 microhms, and at the point of complete melting (940° C.) the resistivity had risen to 44.6 microhms. From this point, as the temperature of the melt rose, the resistance regularly diminished until at 1100° C. it was 40.2 microhms.

Volume Changes in Alloys.[3]—Expansion upon solidification, in case of copper-tin alloys (90 per cent. Cu), of copper-zinc alloys (85 per cent. Cu), and of aluminium castings are considerable, ensuring sharp, well-filled-out castings. On slowly heating the copper-tin alloy contraction took place, due to the liquidation of β crystals, the liquid filling cracks existing in the casting. On cooling slowly, extraordinary expansion resulted, apparently due to the chilling of the liquid round α dendrites. By repeating the heating-up and cooling-down operations five times, a bar of 10 in. was found to have grown to 11½ in.

Phosphorus in Copper-Aluminium Alloys.[4]—On alloys of 5 to 10 per cent. aluminium, and with phosphorus up to 1 per cent., it was found with 0.2 P present, the quality of hot-rolling fell off, though the cold-rolling quality was improved. In chill castings, up to 1 per cent., the yield-point was raised with a maximum ultimate stress at 0.5 per cent. Phosphorus hardens above 0.25 per cent.; it reduces both the melting point and electrical conductivity.

Copper-Tin-Zinc Alloys.[5]—S. L. Hoyt, in a paper entitled "Copper-rich Kalchoids," before the British Institute of Metals, discusses these ternary alloys high in copper. He finds that up to 50 per cent. zinc and 30 per cent. tin these alloys behave similar to the binary alloys copper-

[1] *Eng. Min. Jour.*, **98**, 107.
[2] *Met. Chem. Eng.*, **12**, 161.
[3] *Trans. (British) Inst. of Metals*, Sept., 1913.
[4] *Trans. (British) Inst. of Metals*, Sept., 1913.
[5] *Met. Chem. Eng.*, **12**, 30

zinc and copper-tin. The eutectoid line was found to have a maximum near the middle corresponding to Cu 66 per cent., Sn 17, and Zn 17 at 590° C., the β solid solutions being isomorphous, and when quenched, producing homogeneous solid solutions. Addition of tin to the brasses caused the visible break-down of the β solid solution. Professor Hoyt finds a field, off the α plus β range in the bronzes, in which two heating effects in the solid are observed.

Analyzed Qamples of Brass.[1]—The Bureau of Standards, Washington, D. C., is prepared to issue an analyzed sample of brass approximately of the following composition, viz: Sn, 1 per cent.; Pb, 1; Cu, 70.3; Zn, 27; Fe, 0.3; Ni, 0.5 per cent. A fee of $3.00 is charged for a sample of 150 grams.

Improving the Quality of Arsenical Copper.[2]—When arsenical copper is brought to tough pitch it still contains some oxygen. If such copper is remelted, with addition of a copper-silicon-iron alloy, it becomes deoxidized, the silicon being the more effective deoxidizer, though the iron has a greater strengthening effect. As a result, ductility, toughness, tensile strength, as well as resistance to reducing gases at high temperatures, are increased, and the copper becomes well suited to use for staybolts, rivet-wire, etc.

Copper and Titanium Alloys.[3]—Research work on additions of titanium to copper and brass in making castings indicates that titanium acts as a deoxidizer, and so aids in producing sound castings.

Construction Costs

Cost of Erecting a Wedge Roaster.[4]—The cost of erection of a 22½-ft., seven-hearth roaster is thus given: Erecting steel work, $782.88; equipping arms, $42.00; erecting brick-work, $932.22; carpenter work, $146.00 and supervision, $273.57 or a total of $2177.37. Compare this with the cost of erection of one of eight six-hearth Herreshoff roasters, 21 ft. 7¼ in. diam., viz., $1274.00.[5]

Cost of Reverberatory Furnace Bottom.[6]—The cost for labor and materials for tamping in the 24-in. sand bottom of a furnace 19 by 112 ft. at Garfield, Utah, was as follows:

200 tons of silica sand delivered at the furnace			$31.26
Unloading of silica sand delivered at the furnace			18.18
Making wood tampers			8.25
Labor tamping bottom—Foreman, 3½ shifts		$10.50	
	Laborers, 42½ shifts	74.37	
	Furnacemen, 6 shifts	21.00	
	Furnace helpers, 18 shifts	36.00	14.87
Sundries			3.15
Total			$503.71

[1] *Met. Chem. Eng.*, 12, 81.
[2] *Met. Chem. Eng.*, 12, 648.
[3] *Min. Sci. Press*, 109, 983.
[4] *Eng. Min. Jour.*, 98, 425.
[5] *Bull. Am. Inst. Min. Eng.*, p. 1578, July, 1914.
[6] *Eng. Min. Jour.*, 98, 70.

Smelter Construction Costs.[1]—E. Horton Jones has given us an epoch-making paper on the detailed costs of the Arizona Copper Co. smeltery, Clifton, Arizona. Construction, begun in February, 1912, was completed in two years' time (Feb., 1914).

We give the following summary, and the unit costs, based upon the total less the indirect and engineering expense as 100 per cent.

		Per cent.
Engineering expense	$100,649.88	5.4
Indirect expense	140,277.72	7.5
All other expenses	1,864,092.47	100.0
Total cost	$2,105,020.07	112.9

The "all other expenses" are thus summarized:

		Per cent.
Bedding plant and bunker bins	$150,939.05	8.1
Boiler and blacksmith shops	21,449.23	1.2
Chimney	45,471.34	2.4
Crushing plant	9,268.62	0.5
Converter dust-chamber	27,813.58	1.5
Converter plant	216,033.37	11.6
Converter flue	7,602.88	0.4
Conveying system	45,411.15	2.4
General office	1,394.95	0.1
Laboratory	6,144.02	0.3
Machine and carpenter shop	27,356.27	1.5
Miscellaneous accounts	37,186.48	2.0
Oil-supply sump and pump house	40,611.88	2.2
Power plant	434,703.15	23.3
Receiving bins	44,185.06	2.4
Reverberatory plant	328,945.02	17.5
Reverberatory flue	13,453.70	0.7
Roaster dust-chamber	49,644.76	2.7
Roaster dust-chamber flue	12,859.10	0.7
Roasting plant	136,734.87	7.3
Sampling plant	34,108.74	1.8
Sample room	2,826.11	0.2
Warehouse	13,602.71	0.7
Yard tracks and industrial system	156,326.43	8.5
	$1,864,092.47	100.0

The cost of putting in plain concrete averaged for labor $2.85, for materials $4.82, or a total of $7.67 per cu. yd. Often the cost exceeded this, being sometimes double. The miscellaneous concrete averaged for labor $2.99, for materials $5.36, or a total of $8.36 per yd., but with a maximum rather less than that of the plain concrete. Reinforced concrete was of course more expensive, the labor cost averaging $5.87, the materials $7.66, or a total of $13.53 per cu. yd. Singularly, the maximum cost was no more than $16.35 per yd.

Where plain concrete floors were put in, 4 or 5 in. thick, the cost for labor averaged $0.08, for materials $0.13, making a total of $0.21 per sq. ft. or, computed on a basis of 4 in. thick, $5.67 per cu. yd. These floors were laid in blocks 5 to 6 ft. square, having a finished top and sand joints between the squares. Some reinforced concrete floors were used 4½ to 5 in. thick. These cost on an average $0.18 for labor, $0.23 for

[1] *Bull. Am. Inst. Min. Eng.*, July, 1914, 1497–1651. Published separately as "Smelter Construction Costs" by the McGraw-Hill Book Co.

material, or a total of $0.41 per sq. ft. The power plant main floor, laid on Berger plate, reinforced and finished, cost $0.45 per sq. ft. At the cooling tower a reinforced concrete floor, laid on the ground, cost but $0.17 per sq. ft.

A coping on several of the buildings 12 in. deep cost $0.50 per running ft., or when 18 in. deep, $0.66 per ft.

Excavation, including shallow work done by hand, with a haul of less than 100 ft., averaged $0.86 per cu. yd. It ran as low as $0.54, and as high as $1.30 per yd. When the haul exceeded 100 ft., then the cost increased to $0.95 per yd.

The cost of electric lighting per drop is quite variable, being from $1.38 to $9.55 for labor, and from $1.12 to $7.70 for material, while the average is $4.84 for labor and $5.85 for material, a total of $10.69 for the installation of each of the 563 drops.

The average cost for engine machinery, erected, was $13.59 per cwt., in which was included $0.92 for erecting it, being 7.3 per cent. of the machinery f.o.b. at the works. The traveling cranes, clinkering machines and casting machines cost, erected, $10.03 per cwt., of which $0.97 or 10.7 per cent. of the costs of the machines was the cost of erection. Machines needing little labor for erection, except lifting their heavy parts into place, cost $12.72 per cwt., of which $0.56 was the cost of erection.

Masonry cost for labor was $4.03, for materials $2.17, or a total of $6.19 per cu. yd.

The cost for painting concrete averages $0.74, for corrugated iron $0.67 per square of 100 sq. ft. Other painting was as low as $0.37 per square.

As an example of the cost of roofing, using 2 by 8-in. sheathing and asbestos roofing, but not including painting, the cost was $4.06 for labor and $12.40 for materials, a total of $16.46 per square.

The shafting, pulleys and belting lumped together averaged, per running ft. of the shafting employed, $1.24 for labor and $11.20 for materials, being a total of $12.44 per running ft. However, the materials varied from $5.91 to $22.01 per ft.

The cost for structural steel was $87.03 per ton, erected.

Tile walls averaged $0.48 per cu. ft., unloading brick and tile $0.45 per ton.

The cost for doors and windows per sq. ft. of openings was $0.44 for wooden sash in corrugated iron buildings, $1.26 for steel sash in steel and tile curtain-wall buildings.

Wood-work averaged $23.26 for labor, $29.29 for material, or a total of $52.55 per 1000 ft. board measure, erected.

The cost of the buildings alone averaged $2.57 per sq. ft. or $0.145 per cu. ft., and when equipped, $6.40 per sq. ft. or $0.32 per cu. ft.

Comparing the cost of storing ore, the receiving bins cost $3.34 per cu. ft. of capacity, while the bedding plant including the bunker bins was but $0.66 per cu. ft. of capacity.

The cost of a complete belt-conveyor is given at $34.47 per ft., measured from the center of the head to the center of the tail-pulley.

Flues average $0.45, and dust-chambers but $0.25 per cu. ft.

The power plant, including the boilers, cost per indicated horse power $55.32, not including the boilers, $37.40. The boiler plant alone, having a total of 6143 h.p., cost $31.11 per boiler horse power.

The cost of the reverberatory plant, including three furnaces of 400 tons daily capacity each, was $172,171.55 or $57,388.00 per reverberatory. This equals $143.47 per ton treated in 24 hr.

The roasting installation of eight roasters cost $136,734.87, being $17,091.86 per roaster. Including the roaster building the installation totals $199,258.73 or $24,907.34 per roaster.

Tracks cost $2.71 for labor, $1.94 for materials, a total of $4.64 per running ft.

Common labor cost $2.00 per day of 9 hr.; skilled mechanics get as much as $4.50 per day.

The paper concludes with a valuable table giving the cost of the raw materials of construction to which we refer the reader.

Hydrometallurgy of Copper in 1914

By Thomas T. Read

During 1914 progress was made along many lines of copper hydrometallurgy but without bringing about any very radical departures from the lines of work laid down in preceding years. Sulphuric acid has become more strongly intrenched as the most promising solvent, since the work of both Frederick Laist at Anaconda and Utley Wedge at Ajo has proved that the use of a chloridizing roast does not, at those places, produce sufficient additional advantage to compensate for the difficulties which it introduces. The difference of opinion as to whether precipitation by electrolysis or by the use of iron is most practicable continues, and much of the experimental work is being devoted to attempting to solve the questions involved. The only marked innovation during the year was the announcement that C. H. Benedict had devised a leaching process for the Calumet & Hecla tailing in which the copper will be dissolved in an ammoniacal solution, the reason for the adoption of this

process being that the amount of calcite present in the ore is too great to permit the use of acid or acid salts. Contracts had been let for the first unit of construction of the leaching plant when the outbreak of war in Europe caused the suspending of construction work. No practical results have been obtained yet, therefore.

The work which has been done in attempting to determine the most satisfactory process for the treatment of the ores of the Ajo mine, recently acquired by the Calumet & Arizona Mining Co., is fairly representative of last year's progress. The work so far accomplished was ably summarized by L. D. Ricketts in an address delivered before the New York Sections of the American Institute of Mining Engineers and the American Electrochemical Society on January 6, 1915. This address has been published, and a summary of it will serve to indicate the present status of the investigation.

Exploration work on the property has disclosed about 40 million tons of proved ore, containing about 1.5 per cent. copper. Of this, 12 million tons is oxidized, 24 million is sulphide, and 4 million tons of mixed oxide and sulphide separates the two parts of the ore-body. The rock mass in which the ore minerals occur is granite, with a large amount of secondary quartz replacing feldspar, while only a small amount of soluble calcium minerals are present, so that the ore is well adapted to leaching with acid. Preliminary tests showed that when the ore is crushed finer than 6 mm. the copper minerals present will dissolve quite freely in sulphuric acid, although a small amount of cuprite which is present is only partly soluble. Stuart Croasdale was employed to carry on the investigation of leaching with sulphuric acid and precipitation on iron. The results of his work have been presented in considerable detail in two papers published during the year. The first[1] deals with the chemistry of the action of iron sulphides on copper solutions and is of great importance from the standpoint of the study of ore deposits, as well as in the hydrometallurgy of copper. The original paper should be consulted, but the most important results from a metallurgical standpoint may be summarized by saying that pure iron sulphide can be used to precipitate metallic copper from solutions. However, only 25 per cent. of the iron passes into solution and the highest grade copper precipitate obtainable will not contain more than 18 per cent. copper, so that from the standpoint of cost the process does not seem feasible. Matte containing more than 5 per cent. of copper loses its precipitating power and is of no value for this purpose. Certain natural sulphides of iron precipitate copper from their solutions and can be used for this purpose; others do not exhibit this action, and the value of any given sulphide for this purpose can be determined only by experi-

[1] *Eng. Min. Jour.*, 97, 745 (Apr. 11, 1914).

The second[1] paper contains the detailed results of the experi- work on the Ajo ore from the first preliminary experiments with s processes to the final summation of results. In the main experi- the ore, containing 1.5 per cent. copper, was crushed to 2 mesh and nd leached with 10 per cent. sulphuric acid solution. In order to rious types of construction 5 leaching vats, each 5 ft. diam. and ep, were constructed of concrete. The first was made of concrete with "Toxement," plastered inside with cement mortar mixed with ment," and given 3 coats of R. I. W. No. 89 paint. The second e same construction as the first, but was given two coats of hot t. The third, fourth and fifth were made of oil-mixed concrete, ed with oil-mixed cement mortar, and painted with various com- ns of asphalt paint and R. I. W. No. 89. The results of the mental work showed that none of these protective coatings would the acid and especially the hot wash water for more than 48 hr. nade of concrete and lined with acid-proof brick laid in asphalt l to be the most satisfactory. The following summary of results n by Mr. Croasdale.

treated, lb.	384,784
ore, per cent.	1.43
per in ore, lb.	5,526
copper in ore (soluble in H_2SO_4 and lixiviant), lb.	5,097
eaching, hr.	80
washing, hr.	10
tailing, per cent.	0.32
per in tailing, lb.	1228
opper in tailing, per cent.	0.21
uble copper in tailing, lb.	799
tailing insoluble in H_2SO_4, lb.	429
per extracted from ore, lb.	4298
per extracted from ore, per cent.	77.8
ccounted for in solution, including that from oversize in Test 1, lb.	4269
ccounted for in solution, including that from oversize in Test 1, per cent.	97
per extracted from ore based on weight of tailing at 97 per cent. of ore, lb.	4336
per extracted from ore based on above weight of tailing, per cent.	78.5
r available copper extracted from the ore, per cent.	84.3
r available copper extracted from the ore based on above weight of tailing, per cent	84.7
xtracted per ton of ore, lb.	22.34
xtracted per ton of ore based on above weight of tailing, lb.	22.50
trength of acid used, per cent.	8.9
l (100 per cent. H_2SO_4) per lb. of copper dissolved, based on the difference in free...	
the lixiviants going on and going off each charge, as found by analyses, lb.	3.6
l (100 per cent. H_2SO_4) per ton of ore above basis, lb.	80
l (100 per cent. H_2SO_4) per lb. of copper dissolved, based on the total combined acid by analyses in all the solutions sent to precipitating tanks, wash waters, and lixiviants d to storage, lb.	3.15
l (100 per cent. H_2SO_4) per ton of ore on above basis, lb.	67
s used per ton of ore, gal.	128
ter used per ton of ore, gal.	268
required to cover 1 ton of ore after saturation, equals one volume, gal.	34
ercolation through ore, in. per hr.	78
ercolation per sq. ft. of filter area, gal. per hr.	10

e production of sponge iron from leached calcine for the purpose of itating copper from the sulphate solution is described in some detail paper. A Wedge double-function muffle furnace of special design nployed for the purpose, the idea being to roast on the upper

[1] hing experiments on the Ajo ores, by Stuart Croasdale. *Bull. Am. Inst. Min. Eng.*, August, 1881; *Min. Sci. Press*, Aug. 8, 15, 22, 1914.

hearths and metallize on the lower muffle hearths which are heated by oil. It proved impracticable to combine roasting and reduction in a single furnace, and Mr. Croasdale believes that a shaft furnace would be more satisfactory. In the multiple-hearth furnace it was found that the CO_2 present reoxidized the iron which had been reduced. It was also difficult to discharge and cool the sponge iron without allowing it to reoxidize. As mentioned later, the general belief now is that this method of procedure is not commercially feasible. Mr. Croasdale concludes by giving some data on precipitation with pig iron and electrolytic precipitation, for which reference should be made to the original paper.

At the same time work was being carried on by Utley Wedge, who demonstrated that in calcining the sulphide concentrate at the Calumet & Arizona smelter at Douglas the SO_2 gases produced could be utilized in manufacturing sulphuric acid of 55 to 60° Bé. at a low operating cost and at a construction cost of not over $3000 per ton daily capacity. Mr. Wedge also studied the possibility of the use of chloridizing and sulphatizing roasts. As already stated, these experiments indicated that the advantages of chloridizing roasting were not sufficient to compensate for the disadvantages. He found, however, that using mixed oxide and sulphide ore crushed to pass a 20- to 30-mesh screen and properly roasted at a temperature not much above red heat the minerals are converted into sulphates and can be leached with water, yielding a comparatively pure sulphate solution which can be electrolyzed, regenerating sulphuric acid for use in leaching. The disadvantage is, of course, the difficulty of roasting finely ground material and the equally well-known difficulties of the leaching of fine material. Most of the experimenters in the leaching of copper ores have endeavored to work with as coarsely ground material as practicable. Those familiar with the history of the development of the cyanide process for gold and silver are inclined to believe that the copper metallurgists will repeat the experience of the precious metal men and find that the apparent attractions of the cheap and simple leaching of coarse material are counterbalanced by the low extraction secured from coarse material, eventually finding that the extra cost of fine grinding and the difficulties of handling finely ground material are counterbalanced by a corresponding increase in recovery. This statement must be qualified by drawing attention to the fact that the gold and silver metallurgists are dealing with a valuable material and the copper metallurgists with a cheap material; the matter cannot be decided merely on the basis of percentage recovered, but is primarily a question of dollars and cents as to treatment costs and value of the product recovered.

In the precipitation of copper from solution at Ajo the use of iron

was first tried and preliminary tests indicated that with a cheap quality of Alabama pig iron employed for the purpose, the leaching operations and precipitation would show a profit at a price of 12 c. for the copper produced. The cost of iron for this purpose is so high, however, that various other methods have been tried in order to reduce the precipitation costs. The production of metallic iron by the reduction of the iron oxide produced in calcining and leaching sulphides was tested on an extensive scale at Ajo, and a similar set of experiments was later carried out by Frederick Laist at Anaconda. The aim was to produce the iron in a spongy metallic form by the use of fuel oil or hydrocarbon gas in a reverberatory furnace or a McDougall roaster. The outcome of the work in both cases served to demonstrate that while some of the iron oxide could be reduced to iron in this way, the percentage of CO_2 produced was so great that it reacted on the iron and reversed the reducing action of the CO. Mr. Laist found, however, that by the use of a revolving drum and an intermittent process the production of sponge iron was practicable. The work which is now being done on electrolytic precipitation is of such encouraging character that the experimenters have lost interest in the use of sponge iron for reduction. It should be added here, however, that at the leaching plant which the Utah Copper Co. is going to erect iron will at first be used for reduction, though the management stated that it is quite possible that electrolytic precipitation will be introduced as soon as the necessary experimental work could be successfully carried out.

C. R. Van Arsdale has done a large amount of work on the use of SO_2 in the precipitation of copper. It was first proposed to use the well-known reaction by which at high temperature and high pressure SO_2 will precipitate metallic copper from a solution of its sulphate. The practical difficulties involved in handling large amounts of hot solutions at high temperatures are so evident that Mr. Van Arsdale discontinued work along this line and has chiefly confined his attention to the use of SO_2 as a depolarizer in electrolysis.

More recently E. R. Weidlein[1] and Raymond F. Bacon have done a large amount of experimental work in the precipitation by SO_2. No very detailed statement of the success so far attained has been made public, but it is known that difficulty was found in attempting to produce the SO_2 required from ordinary smelter or roaster gases. Meanwhile certain investigators in eastern states, who have not yet given out the result of their work for publication, have made much progress in the production of liquid SO_2 as a commercial product. The advocates of SO_2 precipitation point out that the temperatures and pressures involved

[1] The Weidlein Leaching Process, *Min. Sci. Press*, April 4, 1914, p. 575.

are less than those commonly employed in an ordinary steam boiler. Probably before the end of this year more of detail will be available as to the results obtained in the experimental work on this process.

If it is permissible to precipitate the copper in the form of sub-chloride, using SO_2 gas, only moderate temperature and pressure are required. Frederick Laist has done much work on this process. Adding a soluble chloride to the copper sulphate solution and introducing SO_2 at a temperature of 90° C. gives a fairly complete precipitation of the copper as sub-chloride. This only leads up to new difficulties, however, since the reduction of copper from the sub-chloride involves the possibility of loss by volatilization and it is also necessary to recover the chlorine in order to keep the cost within bounds. The difficulties involved in such processes as this have served to deter many of the investigators from further experiment, and as a result the larger number of workers are directing their efforts toward the control of solutions so that ordinary electrolysis may be used for the precipitation of copper.

The work along these lines on the Ajo ore has been chiefly performed by Fred J. Pope and A. W. Hahn and by F. L. Antisell. The work done by Pope and Hahn is essentially a modification of the Hoffman process, at one time employed at Argentine, Kan. They employed an experimental plant of 10 tons daily capacity, using carbonate ores from Ajo. The first solution used contained 2.5 per cent. of free sulphuric acid and was circulated until it had become nearly neutral. The neutralizing precipitated out of the solution upon the ore a considerable part of the iron and aluminium present in the solution. The neutralized solution was drawn off and acidified by mixing it with electrolyte from the electrolytic tank where the copper is precipitated in the ordinary way. The ore from which the solution has been drawn off is treated with fresh acid solution which re-dissolves the iron precipitated from the first solution, and also dissolves more iron from the ore. The solution is circulated until it becomes nearly neutral when it is replaced by fresh solution carrying 4 to 4.5 per cent. of free acid, the total leaching period averaging 80 hr. The solution high in iron thus produced is then subjected to a purification process. In this process the solution is first heated nearly to boiling and agitation with air is then begun with the gradual introduction of oxide ore which has been ground so that 93 per cent. of it will pass through a 200-mesh screen. Agitation with air is then continued for $3\frac{1}{2}$ hr., most of the ferric iron being precipitated during the first hour and most of the ferrous iron in the remainder of the period. At the end of the operation 90 per cent. of the iron, 65 to 75 per cent. of the Al_2O_3, 50 per cent. of the Mn, and all of the arsenic, antimony and bismuth present have been precipitated. The solution is filtered in a Schreiber wooden

press and the clear solution is sent to the electrolytic precipitation vats. For the electrolytic precipitation anodes of antimonial lead containing 4 per cent. antimony were used, in the form of grids and sheets. The voltage required was 0.3 volt higher with grids, and sheets were therefore adopted. The expected loss of lead did not prove serious and it has been estimated that the cost of lead anodes with lead at 8 c. per lb. would be less than 0.2 c. per ton of ore treated.

The advantages and disadvantages of the process have been summarized by F. J. Pope as follows:

ADVANTAGES

(*a*) Simplicity.
(*b*) All steps in the process have been in use in commercial practice for many years.
(*c*) Saturated solutions are avoided.
(*d*) Wash water not excessive.
(*e*) Impurities which would have injured the quality of the cathode are eliminated from the electrolyte.
(*f*) Acid control simple.
(*g*) No steps in the process are dependent on careful adjustment.

DISADVANTAGES

(*a*) Two strengths of acid solution used, necessitating more solution storage tanks, solutions, lines and pumps than with a single solution.
(*b*) Purification of electrolyte is an extra operation involving the installation of roasting furnaces, boilers, compressor and filter press.
(*c*) The lead anodes will probably have to be changed every 4 or 5 months, since the lead peroxide formed increases the voltage.

In the process devised by F. L. Antisell leaching is performed by circulating the sulphuric acid solution containing iron and aluminium. A portion of this circulating solution is continuously drawn off and passed through an absorption tower where it absorbs SO_2 gas which serves to reduce the iron. As might have been expected, difficulties were found in the absorption of SO_2 in the tower. The solution thus reduced is electrolyzed, using an anode composed of a narrow rectangular wooden or lead frame with thin wooden diaphragms forming a deep, narrow box which is packed with coke crushed to 1-in. size. This

process has been tested on a working scale at Douglas, Ariz., with the result that 80 per cent. of the copper content of the ore is extracted, nearly 2 lb. of copper per kw.-hr. and the production of nearly the theoretical amount of sulphuric acid from the SO_2 gas.

As a result of all this work a new process has been devised by Greenway of which the details are not yet released for publication. In the preliminary work on this process it was found that using ore crushed to 0.25-in. size an extraction of over 80 per cent. of the copper present could be secured. By a counter-current system difficulty with the triad salts is avoided and although the iron content of the solution has reached as high as 1.2 per cent., a recovery of 1 lb. of copper per kw.-hr. has been secured from the electrolytic tank. As a result of this a 40-ton plant is under construction in which the process can be thoroughly tested. There are therefore under investigation now at Ajo three processes: the Greenway process, the Antisell process, and the modification of the Hoffman process devised by Pope and Hahn. Probably before the end of the year the relative advantages of these three will be fully demonstrated.

In the experimental work done by R. C. Canby[1] on the partly oxidized ore from the Keystone and Miami mines the ore is crushed by rolls to 8 mesh and concentrated on a dry jig, by which about two-thirds of the sulphide present is recovered as concentrate. The tailing is sent to a single-deck roaster to convert the insoluble natural oxide of copper into the soluble form, after which the ore will be leached by percolation. It is proposed to electrolyze the copper-bearing solution, using lead anodes and employing SO_2 as a depolarizer. The fine material made in crushing is separated but no mention is made of what disposal is made of it.

The results of the experiments in the 80-ton leaching plant at Anaconda were presented[2] by Frederick Laist and H. W. Aldrich at the August meeting of the American Institute of Mining Engineers. This paper is full of interesting details as to operation; its essential features may be condensed as follows:

The material which is being subjected to the leaching process is the sand tailing from the concentrating plant. This contains 13 to 14 lb. of copper per ton and 3 per cent. sulphur. Of this material about one-half is reclaimed on a 40-mesh screen and only 5 per cent. will pass 200 mesh. This is roasted in a six-hearth, 20-ft. McDougall roaster, which handles 80 to 90 tons per day, reducing the sulphur present to 0.6 per cent., about four-tenths of the copper present being soluble in water. It was at first proposed to add salt upon the lower hearths of the roaster in order to chloridize the silver, of which a little more than 0.5 oz. per ton

[1] *Eng. Min. Jour.*, 97, 310 (Feb. 7, 1914).
[2] Experimental Leaching at Anaconda, by F. Laist and H. W. Aldrich. *Bull. Am. Inst. Min. Eng.* August, 1914, p. 2165.

naterial treated is present. Experiment demonstrated, however, t this led to the volatilizing of a good deal of the copper as chloride, that by simply roasting in the ordinary way a better recovery was le of the copper, while the silver could be recovered by the use of a ng salt solution produced by spreading a layer of salt over the hed calcine just before the addition of the wash water. In this way r 70 per cent. of the silver can be recovered at a less working cost, responding to a greater operating profit as compared with attempt- to secure a higher recovery. It is expected that regular operation yield a copper recovery of 85 per cent. and a silver recovery of 75 cent., corresponding to 12 lb. of copper and 0.4 oz. of silver per ton ated. The copper will be precipitated upon scrap iron, which also gs down the silver.

In the discussion of this paper[1] Lawrence Addicks points out that the duction of a suitable deposit is contingent on the presence of enough per ions, which can be secured by using either a concentrated solution a dilute solution which circulates rapidly, the proposal being to remove y a small part of the copper from the electrolyte, returning the ution for further leaching and using counter-current washing with rr classifiers and thickeners. He also called attention to the fact that wood has remarkably high resistance to acid solutions, and apparently s not require protective coatings. He also suggests that the solution alumina may be restrained by keeping the leaching solution high in Al ts. Further details in regard to precipitation at Anaconda are given an earlier paper[2] by Frederick Laist. This is one of the most interesting d valuable papers of the year. The authors state that the choice of a cipitation method hinges on the following factors:

1. Availability of precipitant.
2. Adaptability to the leaching process.
3. Final product desired.
4. Regeneration of leaching solutions.
5. Fouling of solutions.

The authors investigated three groups of processes:

1. Precipitation by iron, scrap or sponge.
2. Electrolytic deposition.
3. Precipitation by gaseous reagents.

Of gaseous reagents H_2S was first tried, being generated by the action H_2SO_4 on ground matte. The advantages of its use are that the action regenerates H_2SO_4 for use in leaching, there is no fouling of solu-

[1] *Bull. Am. Inst. Min. Eng.*, Nov., 1914, p. 2728.
[2] Precipitation of Copper from Solution at Anaconda, by Frederick Laist and F. F. Frick. *Bull. Am. Inst. Min. Eng.*, July, 1914, p. 1425.

tions, the precipitate can be added to the sulphide concentrate in ordinary smelting operations. Unfortunately it proved impracticable to get good absorption of the H_2S in the solution to be precipitated, the gas bubbling through and escaping. The reaction by which H_2S precipitates CuS from $CuSO_4$ solution is also easily reversible, and the finely divided CuS will easily oxidize to $CuSO_4$ on exposure to the air. The use of SO_2 is suggested to precipitate Cu_2Cl_2 from the pregnant solutions. One pound of SO_2 will thus precipitate 2 lb. of copper as Cu_2Cl_2. The precipitated cuprous chloride is then mixed with sponge iron, producing copper and ferrous chloride. This saves one-half of the iron required to precipitate copper from the cupric salts. It is suggested that the SO_2 required can be secured from the gases of roasters in which sulphide concentrate is treated. It has previously been pointed out that experiment elsewhere indicated that it is impracticable to obtain a sufficient concentration of SO_2 from roaster or smelter gases. It is intimated that the chlorine of the ferrous chloride may be recovered, but no process is suggested. Reduction of the Cu_2Cl_2 with coke in the presence of limestone was then tried. The difficulty with this is that the chloride is volatilized. It is suggested that the Cottrell process might be employed to catch the fume. The electrolysis of the Cu_2Cl_2 was also tried. This has the advantage of requiring only one-half the electric energy necessary to dissociate cupric chloride, but has the marked disadvantage that Cu_2Cl_2 is a solid and requires to be protected from the oxidizing gases given off at the anode. A horizontal diaphragm-cell, circulating depolarizing solution and a graphitized carbon anode were employed. The work was discontinued before the experiments were brought to a satisfactory conclusion, but the authors of the paper regard the cell as capable of development.

Ordinary electrolysis of the solution is not practicable at Anaconda, as the solution contains large amounts of chlorides, which must be present in order to take the silver in the ore into solution.

The production of sponge iron and its use in precipitation is one of the most interesting features of this paper. Concentrate high in iron was roasted in McDougall furnaces, yielding a product containing 56 per cent. Fe. This was mixed with ground Diamondville coal in the proportion of 70 per cent. calcine and 30 per cent. coal. This was charged into retorts something like those used for the production of spelter, and heated to 1600° F. for 4 hr. It was then discharged into air-tight cars to prevent re-oxidation on cooling; 2.2 to 3 lb. of the product would precipitate 1 lb. copper. The time required for reduction (24 hr.), the cracking of retorts which allowed air to leak in, and the low fuel economy led to the abandoning of this method. The reduction of hot calcine on the lower

hearths of a McDougall furnace was next tried, but proved utterly impracticable. Finally a rotating cylinder, 5 ft. diam. and 12 ft. long, much like a Brückner roaster, was constructed. Hot calcine is charged into this, 40 per cent. of ground coal is added and the cylinder rotated for ¾ hr., when the hydrocarbons are burned off and the charge thoroughly mixed. An oil-burner is then directed into the rotating cylinder for about 2 hr., when the reduction is complete and the contents can be discharged. By screening the product, coke amounting to one-fourth of the coal used is recovered. Of the quenched sponge 1.7 lb. will precipitate 1 lb. copper. The temperature used should not exceed 1700° F.; 20 gal. of fuel oil per ton of calcine is required for heating. The method is still in progress of development, and the authors of the paper expect it to prove a commercial success. In the discussion of this paper[1] Stuart Croasdale points out the certain changes which would have led to a better absorption of H_2S and argues that the use of SO_2 as a precipitant can never be economical since it involves introducing a precipitant into a cold lixivium, heating the whole mass and cooling it again to produce a precipitate which requires further treatment. In reply Mr. Laist states that undoubtedly a better absorption of H_2S might have been obtained, but that the preliminary experiments indicated that the cost of precipitating in this way was too high to justify further experiment. As regards SO_2 he concluded that the pressure required is the same as in ordinary converter practice, and suggests the use of counter-current apparatus in which the hot solution can be made to heat the cold solution; and states that his calculations indicate the precipitation with SO_2 can be performed at a cost of $10 per ton of copper produced, without crediting the acid regenerated.

A detailed account of the method to be used at Chuquicamata was presented[2] by E. A. C. Smith at the April meeting of the American Electrochemical Society. At the January meeting of the New York Sections of the American Institute of Mining Engineers and the American Electrochemical Society, Mr. Smith gave the following condensed statement as to the process and the status of the work: Our plant is practically finished; the leaching plant itself, as well as the mining plant, is practically completed. We have been slightly delayed with the completion of the power plant on account of the war in Europe; our plant is being manufactured in Germany, but we have had advice that the steamer on which the remainder of the machinery for the power plant is being shipped has sailed, and we believe it is beyond the danger zone by this time. We hope within the next three weeks at most it will be landed in Chile, and that the rest of the erection work can then proceed. Ac-

[1] *Bull. Am. Inst. Min. Eng.*, Nov., 1914, p. 2729.
[2] *Trans. Am. Electrochem. Soc.*, **25**, 193 (1914); *Eng. Min. Jour.*, **97**, 865 (April 25, 1914); *Min. Sci. Press.*, **108**, 739 (May 2, 1914).

cording to our present plans, we expect to have the plant in operation by the first of April. So far in the construction work everything has gone on very nicely, and it now remains only to start the plant.

The general plan of work consists in steam-shovel mining the copper deposit, followed by leaching the ore. From the crushing plant the ore will be moved by a belt and unloaded by a bridge that straddles the leaching tanks. The leaching tanks, six large concrete vats set end to end, are 160 ft. long, 110 ft. wide and 16 ft. deep. Each tank is designed to hold 10,000 tons of ore. After the ore has been delivered to these by the traveling bridge from the main belt, the first solution is applied by upward displacement. At first we had planned to conduct the operation entirely by downward percolation, but we found a slight tendency of the finer material to clog the filter bottom; also, we found that channels were formed in the charge. These difficulties were entirely overcome when we instituted the method of applying the liquor by upward displacement. The first treatment solution stands on the ore for 48 hr. This solution is immediately followed by the washing liquors in rotation, run on the top of the ore, and displacing the previous solution by the "piston" method. In this way we find that we can wash the ore so that the tailing will contain only from 0.015 to 0.03 per cent. soluble copper. We think this is about the limit, and we can obtain this result without introducing any more water in the process than sufficient to make up for that carried off in the tailing as moisture, and in the solution which is discarded to get rid of the surplus acid produced from the ore.

The solution is removed from the tanks through lead-lined iron pipe, and conducted to a central pumping station, where we will use centrifugal lead-lined pumps, each with a capacity of 5500 gal. per min. against a lifting height of 62 ft. The pumps have been built by the Worthington Company; they have been tested in their shops, and as far as we can tell they are going to be highly satisfactory.

The solution is then delivered to the storage tanks, placed at an elevation above the leaching tanks, and from there it flows by gravity first to the plant where we are going to eliminate the chlorine. We propose to pass the solution through cylinders 30 ft. long and 4 ft. in diam., half filled with shot copper. By this means, the chlorine is precipitated in the form of cuprous chloride. The operation is continuous. The mixture of precipitated cuprous chloride, with the copper sulphate solution containing about 3 per cent. sulphuric acid, is run into Dorr thickeners where the precipitate is separated from the solution. The cuprous chloride pulp corresponds to between 1 and 2 per cent. of the total amount of the solution. We are installing some Kelly filter presses

which are lead-lined, and we are also going to install an Oliver filter, likewise lead-lined, in order to compare the two types.

The filter-pressed material will be delivered to the smelter by the usual methods, and at the smelter it will be mixed with limestone and coke finely crushed (8 to 10 mesh material), put through a pug mill, pressed into briquettes, and delivered to the blast furnace. In the blast furnace will be produced copper, and calcium chloride as a slag. The copper will be taken to a small reverberatory furnace, where it will be granulated and again used in the dechlorinators. We find that on account of oxidizing the agents present in the solution, partly in the form of ferric sulphate and partly in the form of nitric acid, the efficiency of the copper shot is only about 50 per cent. of the theoretical; in other words, there is a direct solvent action on the metallic copper in addition to that caused by the reduction of the cuprous chloride. Practically all of the copper produced in the form of cuprous chloride will go back into the process.

The solution, after the chlorine is removed, is fed by gravity into the electrolytic tanks with a strength of approximately 5 per cent. copper. It will run through the depositing tanks arranged in sections of 16 tanks each, which will have about 13,000 amperes to a tank. The voltage will be about 2.3. We expect a yield of approximately 1 lb. of copper per kw.-hr. The solution will leave the last tank containing about 1.5 per cent. copper. We find that the current efficiency will drop off rapidly if we go lower than 1.5 per cent. By holding to these limits we will have an ampere efficiency of approximately 90 per cent. The solution from the last tank in the cascade will be delivered back to the leaching plant to be used over again. Our problem is somewhat unusual in this respect, in that we have available sulphuric acid present in our mineral, but instead of having to look around for means of producing acid, we have to look for a method of getting rid of the surplus sulphuric acid. We will have to dispose of a quantity of the solution on account of its content of sulphuric acid.

There are no soluble impurities in the ore itself, such as antimony and arsenic. Soluble lime and alumina and alkali salts are negligible. Consequently the usual trouble experienced in connection with leaching processes is not present in our problems. Chloride, which we have in the upper part of the ore-body, was really our most annoying difficulty, but the treatment of the solution with metallic copper has eliminated this difficulty. In addition to this, we also have a small amount of nitric acid in the form of nitrates. So far we have not been able to determine that any special difficulty arises in the process itself from the presence of nitric acid. It has, however, a rather deleterious effect on lead connections, lead pipes, and lead anodes. We have noticed, however, that

this difficulty is only present at points where we are handling the strong solutions, those containing 8, 9 or 10 per cent. of sulphuric acid. We have nitric acid present up to 0.8 per cent. but outside of the difficulty mentioned it does not give any trouble. Its presence does not seem to have any particular function in the process itself, and we have not been able to determine that its being there causes any lower current efficiency. It does not seem to have any effect on the voltage.

Chlorine seems to have a tendency, which was to be expected, of lumping the deposit to a certain extent, and the use of colloids to prevent this does not seem to be very encouraging. I think it will be a question, more than anything else, of watching the deposit, and not allowing the cathode to get quite as thick as in ordinary practice.

Underlying the large oxidized ore-body, at present developed to the extent of 200 million tons, we have a sulphide ore-body. Small scale tests conducted on this material show that it can be treated either by roasting and leaching, or by water concentration followed by smelting in the usual manner. This ore-body is also of enormous extent, but details have not yet been decided upon for the final working of it, as the 200 million tons of oxidized ore already developed will keep us busy for some time to come.

Leaching of flue dust at the Nevada Consolidated Smelter has been[1] described by W. L. Austin. The siliceous flue-dust caught in the dust chambers of the roasting plant is hydraulicked to dams where the pulp settles, and the clear liquor, which contains an excess of acid, is then used to leach oxidized ore, circulating it until it is neutral when it is passed over scrap iron. The cost of the copper thus produced is given as 8 c. per lb.

The most important advance of the year was the devising of a process by C. H. Benedict[2] which does not involve the use of acid. This process is intended to treat the tailing from Wilfley tables in the regrinding plant of the Calumet & Hecla mill. Acids cannot be employed on pulp, as it contains too much calcium carbonate; so the well-known reaction between ammonia and copper oxide will be utilized as the basis for the process. Finely divided copper has at all times on its surface a microscopic film of oxide of copper. If this is subjected to the action of ammonia in the presence of an ammonium salt, such as ammonium carbonate, the film of oxide is dissolved, going into solution as a double cuprammonium salt. If oxygen is present in the solution, the film of oxide is at once renewed and the process is a continuous one until all the copper has gone into solution. This reaction was first employed by

[1] Leaching Copper Products at the Steptoe Works, By W. L. Austin, *Bull. Am. Inst. Min. Eng.*, July, 1914, p. 1779.

[2] The Calumet & Hecla Leaching Process, *Min. Sci. Press*, Sept. 5, p. 361 (1914).

Schnabel, many years ago, and was later used in gas analysis by Hempel for the determination of oxygen. Charles Van Brunt has recently described the use of this reaction for absorbing oxygen from the air in order to generate nitrogen. In his Handbook of Metallurgy, Schnabel discusses its application to the hydrometallurgy of copper in these words: "Experiments hitherto tried along these lines have failed because ammonia-tight vessels were not employed, and because the precipitation of the copper, for which iron cannot be employed, was performed by means of H_2S, CaS, or BaS. By the use of iron vessels, however, the loss of ammonia may be avoided; the copper can be recovered as oxide by distilling off the ammonia, which can thus be recovered." The experiments made in Germany were on natural oxides and roasted ore, Mr. Benedict being the first to apply the method to the treatment of native copper.

In carrying out the process at the Calumet & Hecla, sixteen 1000-ton vats, 54 ft. in diam. and 12 ft. deep will be employed in a 91- to 96-hr. cycle for the treatment of the ore. In treating a sand containing 12 to 13 lb. of copper per ton, 5.5 to 6 lb. will be recovered by the regrinding and table treatment, and 4.5 to 5 lb. will be recovered by leaching. It is estimated that the cost of the leaching will not exceed 35 c. per ton and the recovery will exceed 70 per cent.

The contract for the construction of the plant was let to the Riter Conley Manufacturing Company, and one-half of the 4000-ton plant was in process of erection when the outbreak of the war led to the cessation of work for the time being.

At the meeting of the American Electrochemical Society at New York City, April 16, 17 and 18, 1914, three papers on the electrolytic deposition of copper from solution were presented. Lawrence Addicks discussed the electrochemical problems involved in the deposition of copper. The current density used is fixed by the balance between the difficulties of utilizing the rough deposits produced by high density, on the one hand, and the cost of power and the interest on the metal locked up in the process, on the other. The usual practice is 20 amp. per sq. ft., with an ampere efficiency of 90 per cent. and a deposition of 6 lb. of copper per kw.-hr. The questions concerning voltage and conductivity of the electrolyte are discussed in detail, and reference should be made to the original paper. H. E. Longwell discussed the mechanical side of the generating of power for this purpose, comparing steam turbine plants, gas producer plants, and triple compound engines. He concludes that a good turbine driven plant of 6000 to 9000 kw. can be built for $75 per kw. Allowing 10.5 per cent. for investment charges, using coal costing $3 per ton, and with efficient management operating at 100 per cent. power

factor, he estimated that energy could be produced at 4.3 mills per kw. at the switchboard. F. D. Newbury discussed the construction of the electrical generators for producing direct current for this purpose. This paper will be of considerable interest to anyone who has occasion to construct electrolytic plants.

Of new plants proposed or building the most important is that of the Utah Copper to treat the oxidized ore removed in stripping the sulphide ore-body. No details as to method or construction have been given out, but it is understood that sulphuric acid will be employed to leach and the copper will be precipitated on iron, at least until operations afford opportunity for experiment with other methods. At the Royal Basin mine at Maxville, Mont., John D. Fields has put in operation a patented process which is claimed to be successful, though no details regarding it have been published. The Nevada Douglas is also engaged in erecting a leaching plant, of which the details are also kept secret. The Bull-whacker, described at some length in my review of last year, has shut down, on account of financial difficulties. The Butte-Duluth management claims that work during 1914 has demonstrated that the method there employed, also described last year, is commercially profitable. Bernard McDonald suggests[1] the use of the Parral tank in the hydrometallurgy of copper. The Irving leaching process is described[2] by W. L. Austin. The Slater process is described[3] by H. W. Morse. This is a cyclic hypochlorous acid process. By electrolysis of a 15 per cent. salt solution in which $Fe(OH)_3$ is suspended a mixture of ferric chloride and hypochlorous acid is produced and used to leach ore ground to 40 mesh. After the copper has been taken into solution the NaOH produced in the cathode compartment of the cell is added in quantity sufficient to completely precipitate the iron as $Fe(OH)_3$. The copper may then be precipitated from the clear solution by one of several methods; the use of hot NaOH and air is suggested. This precipitates the copper as CuO, which can be formed into blocks and used as a cathode in the electrolytic cell, producing a decrease in the voltage required as well as yielding metallic copper. These are the only new processes of any importance to be put forward during the year, as most investigators are fully occupied trying to solve the difficulties of familiar processes.

[1] *Eng. Min. Jour.*, Feb. 7, 1914, p. 325.
[2] Irving Leaching Process, *Min. Sci. Press*, Jan. 3, 1914, p. 77.
[3] Slater Leaching Process, *Min. Sci. Press*, Jan. 24, 1914, p. 181.

CRYOLITE

The only occurrence of cryolite that has been developed is situated at Ivigtut, Greenland, the mine belonging to the Oresunds Chemiske Fabriker, Copenhagen, Denmark. Here the product of the mines is treated in part and sold to various consumers or manufactured into chemical products. The production at the mine for the calendar year 1913 amounted to 10,415 metric tons of cryolite. Of this 8451 tons was treated at the works in Copenhagen, and the balance, namely, 1964 tons, was shipped directly from Greenland to the United States. The production for 1914 amounted to 11,512 tons, of which 4139 tons was shipped to the United States and 7373 tons to Copenhagen.

The preparation for the market and the uses of cryolite are described in MINERAL INDUSTRY, **20**, 263.

Formerly cryolite was used in the soda and alum industry and the manufacture of hydrofluoric acid, but now it is used almost entirely for the metallurgy of aluminium and white opalescent glasses and enamels. The Pennsylvania Salt Co. is the sole importer in the United States.

The Department of Commerce reports the following imports for the fiscal year ending June 30:

	Long Tons.	Value.	Price per Ton.
1911	2007	$47,093	$23.50
1912	2126	48,293	22.70
1913	2519	52,440	20.80
1914	2157	47,435	21.99

Canada is also an important producer of aluminium and the importations of cryolite for the year 1912 were valued at $56,591, for 1913, $50,905, and $44,683 for 1914. The cryolite is imported practically entirely from the United States.

FELDSPAR

By Arthur S. Watts

The feldspar industry is peculiar in many ways, the supply of crude material being obtained from a large number of relatively small operations, and a very few large operations, the latter being chiefly producers of low-grade material. The operation of a feldspar property passes through several distinct stages, and the center of feldspar production shifts from time to time as the quality of the output deteriorates.

The original operation of nearly all feldspar properties has been for dental porcelain material, which must be of the highest quality. After this class of material is exhausted, the deposit is generally worked on a larger scale for the best of the remaining material which is sold to operators of older deposits, who must obtain a quantity of high-grade material to mix with their product in order to bring it up to marketable quality. Thus the quality of product produced continues to deteriorate until it must in turn be raised by addition of choice material from more recently opened deposits. The early production from a district establishes the commercial standard of that district and the decline is so gradual that most consumers never realize the change in quality unless some change in physical property is developed through the introduction of some new material.

This method of operation has its advantages as well as its disadvantages. The surface exposures of feldspar are generally of at least as high grade as the material deeper in the deposit, except when a thin layer of gneiss occurs as capping. Hence many deposits are opened for select material found on the surface and cheaply mined and the profit obtained encourages the extension of operations on property which would not otherwise be opened. Also, the practice of working surface deposits has exposed many large lenses of high-grade feldspar of which there was no indication on the surface.

On the other hand, if the practice was followed of exposing a large face of the mineral and endeavoring to maintain a grade of product representing the average of the entire deposit, the user would not be exposed to the dangers of the present system, unless the deposit varied longitudinally, which is not uncommon in igneous intrusions such as these.

In recent years considerable attention has been given to the blending of feldpars, and the gradual exhaustion of many of the older operations has not caused the difficulties that might have been expected.

Of special importance to all feldspar consumers is the knowledge obtained from recent investigations bearing upon lowest fusing mixtures of feldspars.[1]

The potash feldspar (microcline) has heretofore constituted the chief source of flux for the chinaware industries. Its superiority consists of a gradual deformation behavior and thus a longer range of heat treatment is permissible than with a more rapid fusing feldspar such as soda feldspar (albite). Microcline, however, does not become very active as a flux until about the temperature of Cone 9, while albite is active at least one cone earlier. The deformation temperature of microcline is slightly lowered and the rate of deformation is increased by additions of silica up to 15 per cent. Albite has a very short deformation range and its fusion behavior is not accelerated by additions of quartz.

A pronounced deformation eutectic is obtained by a mixture of 30 per cent. microcline and 70 per cent. albite. The deformation range is only slightly decreased and the deformation temperature of this mixture is about three cones below that of microcline. The mixtures higher in microcline have equally long deformation ranges but proportionately higher deformation temperatures. The lowering of the maturing temperatures of white wares by the employment of such blended feldspars is of great industrial importance, as the life of kilns and kiln furniture is thus greatly increased and considerable saving in fuel also results.

Within the years 1913–14 the feldspar mining industry has developed in several districts where heretofore operations were conducted only for dental feldspars. In Ontario, Canada, a number of new operations are reported in the neighborhood of Godfrey, 25 miles north of Kingston. In New York operations are greatly increased both in Fulton and Westchester Counties. In Maryland several large operations have developed in Baltimore County. In Virginia the largest operation in the history of the state has developed in Bedford County. In North Carolina extensive operations are developing in Mitchell and Yancey Counties.

The feldspars of Ontario, Canada, are of the salmon and the white varieties and are microcline intergrown with from 20 to 30 per cent. albite. They are hence of moderate maturing temperature. They are excelled by only a few feldspars mined in the United States as regards color and are practically free from uncombined quartz, the structure of the dike being so massive as to permit of the easy removal of all associated material.

[1] *Bull.* 53, U. S. Bureau of Mines; *Trans. Amer. Ceramic Soc.*, **15**, 144, 451.

Typical analyses of Canadian feldspars are as follows:

SiO_2	66.23	65.40	65.15
Al_2O_3	18.79	18.80	18.65
Fe_2O_3	trace	trace	0.10
CaO	0.31	.....	0.18
MgO	.....	.....	.....
Na_2O	3.11	1.95	4.31
K_2O	12.09	13.90	10.36
Ignition loss	.....	0.60	0.32

The Maine feldspars are cream-colored microcline pegmatites of too intimate crystallization to permit of the elimination of much of the quartz. The color, if properly selected, is considered equal to any known. Only a few dikes of massive feldspar are known to exist in Maine and these are two narrow to justify development for general uses. A few lenses of albite exist in the highly mineralized sections, but these are not of size to justify extensive development.

The Connecticut feldspars resemble the Maine feldspars in most respects, but less attention has been given to fine grinding and much of the Connecticut feldspar is marketed for low-grade purposes.

New York state produces three distinct grades of feldspar. In the neighborhood of Ticonderoga, Essex County, a mixed pearl-gray pegmatite, high in anorthite and so impregnated with biotite as to make refining impossible, is mined and crushed for use in the manufacture of prepared roofing and poultry grit.

In Saratoga County high-grade salmon and cream pegmatite has been worked in on limited scale. These dikes vary in structure and also in composition but all are of coarser crystallization than the Maine pegmatites.

The compositions of the various feldspars are about as follows:

	Saratoga Co., N.Y.	Connecticut	Maine
SiO_2	65.14	66.05	65.07
Al_2O_3	19.38	18.99	19.39
Fe_2O_3	0.29	0.12	0.10
CaO	0.44	.....	.....
MgO	0.14	.....	.....
Na_2O	3.61	3.04	2.68
K_2O	11.28	11.80	12.60
Ignition loss	0.26	0.50	0.15

In Westchester County there are two distinct types of pegmatite associated in the same dikes. One of them is buff to salmon microcline and the other white albite. They are of too fine crystallization to permit of concentration by hand picking of the quartz content and are slightly

igher in Fe_2O_3 than the Maine and the Connecticut pegmatites, but they evertheless fall within the limits of commercial feldspars.

The following are representative analyses of feldspars from Westhester County, N. Y.:

	Microcline	Albite Pegmatite
O_2	64.82	73.88
l_2O_3	18.82	15.73
e_2O_3	0.29	0.36
aO	0.23	0.86
gO	0.16	0.36
a_2O	2.70	7.97
$_2O$	13.11	0.48
nition loss	0.22	0.40

Pennsylvania has no extensive feldspar operations at present, the enrmous albite deposits near the Maryland line at Sylmar being exhausted nd the potash feldspar operations being now limited to a number of omparatively small workings. The largest are at Chester Heights, and t Pomeroy, Chester County. These operations are both coarse mixtures f buff microcline and white albite pegmatites. The Pomeroy operaons are for poultry grit and roof material, although the material is of too igh grade for such uses. Their compositions are about as follows:

Microcline Pegmatities			Albite Pegmatites		
O_2	73.35	72.39	SiO_2	74.60	67.93
l_2O_3	14.60	15.57	Al_2O_3	15.66	20.49
e_2O_3	0.06	0.20	Fe_2O_3	0.05	0.30
aO	0.06	0.13	CaO	2.75	2.60
gO			MgO		
a_2O	2.00	2.27	Na_2O	6.33	6.95
$_2O$	9.11	9.55	K_2O	0.65	0.80
nition loss	0.33	0.30	Ignition loss	0.42	0.60

Maryland feldspars are chiefly cream to buff microcline pegmatites imilar to the Pennsylvania feldspars, but carrying slightly more biotite n most cases. Albite pegmatites are also present, but not so common as n Pennsylvania.

The composition of the Maryland feldspars is about as follows:

Microcline Pegmatite		Albite Pegmatite	
iO_2	74.20	SiO_2	65.32
l_2O_3	14.30	Al_2O_3	22.00
e_2O_3	0.20	Fe_2O_3	0.21
aO		CaO	3.78
gO		MgO	
a_2O	1.59	Na_2O	6.89
$_2O$	9.48	K_2O	1.06
nition loss	0.13	Ignition loss	0.76

The Virginia feldspars are of widely different compositions but are generally of excellent quality. They are not being operated at present, with the exception of the Bedford County deposit of cream microcline pegmatite.

The North Carolina feldspars are chiefly coarse cream microcline pegmatites. These deposits have all been commercially opened within the past 4 years and the quality has proven equal or superior to the Maine feldspars. Whether the quartz content in these deposits will increase with depth cannot be predicted.

Their composition averages about as follows:

North Carolina		Virginia	
SiO_2	64.50	SiO_2	68.75
Al_2O_3	19.38	Al_2O_3	18.56
Fe_2O_3	0.14	Fe_2O_3	0.03
CaO	.....	CaO	1.25
MgO	.....	MgO	.....
Na_2O	2.08	Na_2O	4.29
K_2O	13.09	K_2O	6.85
Ignition loss	0.50	Ignition loss	0.10

The European war has not seriously inconvenienced the users of feldspar, since no pure feldspar is imported from Europe. A substitute for feldspar, obtained from Cornwall, England, is known as Cornish or Cornwall stone, and is imported into the United States in considerable quantities. It is a fine-grained pegmatite carrying fluorspar in sufficient amount to materially affect its behavior. Where this material must be replaced, the following substitution has been found to produce very similar results in pottery glazes. For 100 parts of purple Cornwall stone substitute the following mixture:[1]

Potash feldspar	42.84
China clay	26.71
Flint	34.24
	103.79

The feldspar production of the United States has gradually increased during the past 10 years from 45,188 tons, valued at $266,326, in 1904, to 120,995 tons, valued at $776,551, in 1913.

[1] *Trans. Amer. Ceramic Soc.*, 16, 310.

FLUORSPAR

By Avery H. Reed

ree-fourths of the domestic production of fluorspar and practically
orted fluorspar is used by the basic open-hearth steel industry; and
sequence of the low ebb of steel manufacture in 1914, the fluorspar
ss declined. The production in the United States was about 65
nt. of 1913, and about equal to the production in 1911. The im-
of fluorspar have come principally from Great Britain, and in the
w years have amounted to a tonnage fluctuating above and below
. Moreover, on account of the depressed state of business in this
y and in consequence of England being at war, the importation of
ar to the United States fell off accordingly. American fluorspar
rally directly mine-produced and is mechanically dressed to trade
cations of a minimum of 85 per cent. calcium fluoride and not
ing 6 per cent. silica, while on the other hand imported fluorspar,
lly the English product, is obtained from ancient mine dumps and
r in calcium fluoride content and higher in impurities, and conse-
y is not in as great demand as it used to be before American pro-
n had reached the extent that it has within the last few years.

FLUORSPAR OUTPUT OF THE PRINCIPAL PRODUCING COUNTRIES
(In metric tons)

r.	Austria-Hungary.	France.	Germany. (a)	Spain.	United Kingdom.	United States.
.....	7,061	2,047	13,540	(b)	18,451	33,062
.....	7,601	2,434	13,019	(b)	40,079	52,048
.....	7,795	4,218	15,493	70	42,512	37,002
.....	8,779	4,795	16,624	270	50,257	44,884
.....	7,359	5,456	14,925	253	35,257	46,023
.....	8,106	5,725	14,545	246	43,165	62,970
.....	(c)8,000	8,264	17,988	180	62,607	62,970
.....	*Nil.*	9,502	23,073	490	32,100	78,953
.....	.....	.....	21,023	265	29,152	105,712
.....	.....	.....	.....	.....	.....	104,882

xports. German statistics no longer report production. (b) Not reported. (c) Estimate.

her countries besides the United States and England which pro-
fluorspar are Germany, France, Austria-Hungary, and Spain.
an statistics no longer report production, and the latest available
ics of exports were 21,023 metric tons in 1912; France and Austria-
ary have not furnished any statistics of production lately, 9502
tons in 1911 being the last report from France, and 8106 metric

tons in 1909 being the last report from Austria-Hungary; and Spain reported 265 metric tons produced in 1912, which figure is fairly representative of that country in any year since 1907. According to a report of the *Mining Journal*, a few small veins of clean fluorspar, about 6 to 36 in. in width, exist near Modoc, Hastings County, Ontario, which have been little developed and which have not made a total production of 500 tons.

The market for lump fluorspar for the manufacture of hydrofluoric acid is reported to be improving. This report appears to be confirmed by the increase of nearly 55.8 per cent. in quantity and 91.3 per cent. in value of sales in 1914, in connection with which the price per ton increased about 22.8 per cent.

According to statistics collected by the U. S. Geological Survey, there was marketed in the United States in 1914, 95,116 short tons, valued at $570,041; compared with 115,580 short tons in 1913, valued at $736,286, a decrease of 20,464 tons, and of $166,245 in value. The average price received in 1914, for all grades, was $5.99 per ton, compared with approximately $6.37 per ton in 1913, a decrease of 38 cents.

The states in which economic quantities of fluorspar are produced in this country are Illinois, Kentucky, New Mexico, Colorado, New Hampshire, and Arizona, of importance in the order named. The western states' production is practically all used by the Colorado Fuel & Iron Co., who report that they have been able in late years to obtain from that section all that they require for their open-hearth furnaces.

In Illinois the output in 1914 came from three mines, all in Hardin County. Spar was shipped from ten mines in Kentucky (nine in Chittenden County and one in Livingston County), one mine in New Hampshire, and five mines in Colorado. The mines in Arizona and New Mexico that were active in 1913 reported that there was not sufficient demand for their product to warrant any shipments during 1914.

Illinois.—Two mines at Rosiclare, on the Ohio River, are the main producers of Illinois fluorspar. These are Rosiclare Lead & Fluorspar Mines, and Fairview Fluorspar & Lead Co. In 1914 the former reports a production of about 36,000, and the latter a production of about 33,000 tons.

Rosiclare Lead & Fluorspar Mines operated during 41 per cent. of the year. Development work was carried ahead principally in extending the levels at 320 ft. and at 420 ft., respectively, and considerable breaking of ore and filling of stopes was done, but no further shaft sinking was carried out.

Fairview Fluorspar & Lead Co. continued to extend the upper levels at Blue Diggings operations, and succeeded in finding some other con-

siderable bodies of fluorspar which were mined upon during the year. Also Blue Diggings shaft was sunk to 400 ft. in depth and made ready for further levels. This interest started a new concrete shaft of ample proportions at what they denominate their "Extension" operations, which already included another main working shaft that was sunk a few years ago but which proved troublesome to operate from the one shaft on account of water troubles. "Extension" operations have developed a fine large body of clean high-grade fluorspar, and will likely become a large producer hereafter with the facilities afforded by a pair of working shafts.

Kentucky.—The remarkable thing which happened in this state in 1914 was that the most important operations alive in 1913, and which had such apparent good outlook, suspended operations either early in the year or later, some temporarily and others permanently. Pigmy Mining Co. suspended early in the summer, and at the end of the year sold out their property to Rosiclare Lead & Fluorspar Mines. This step of the largest fluorspar operators already in the district buying an important Kentucky fluorspar property, further strengthens that interest. LaRue Fluorspar Co. operating Asbridge, Tabor, and Pogue mines, closed out their active operations late in the year, permanently, and retired from the fluorspar business. Hoosier Mining Co., which had leased the Tabb property, and which showed promise of developing that important holding into something appreciable, did practically nothing in 1914.

Kentucky Fluorspar Co. was the largest producer in Kentucky in 1914. The principal property of this interest is Yandell mine, where the company put down a new shaft on the old Yandell vein, and encouraged and abetted all the contract mining possible from shallow openings. Besides work at the Yandell mine, this company worked contract miners on their Brown, John Hodge, and other properties.

Memphis mine and Mary Belle mines were the scene of activities for contract mining throughout most of the year, and were operated by Roberts Fluorspar Co.

Near Salem, Livingston County, Ky., Babb mine was operated part of the year, and a shaft was sunk nearly 200 ft. in depth. American Spar Co. operated their Hudson mine, and produced a few hundred tons of high-grade fluorspar which was marketed. Incidentally, in developing the Hudson property for fluorspar, a handsome deposit of carbonate zinc ore was found, and several hundred tons of the ore was marketed, and preparations were made for going after zinc ore on a large scale rather than attempt to exploit deposits of fluorspar in the immediate future.

During the year there was formed and incorporated the West Kentucky Ore Co., which purposes to undertake to exploit the district for

metallic ore values rather than for fluorspar, although that mineral will be marketed incidentally as a by-product. Some valuable properties in Kentucky were purchased, including the Tabb and Mabry properties at Mexico, Ky.; and the old LaRue mine, as well as the adjoining Big 4 mine, were taken control of under lease, and a 50-ton concentrating plant, including equipment of a Denver quartz mill, an Isbell concentrator, and flotation apparatus, was erected at the site of old LaRue mine.

Generally speaking, Kentucky fluorspar operations in 1914 were principally contract mining and the gophering at the surface for gravel or residual fluorspar, and little hard fluorspar was mined below the surface within permanent wall rocks.

Active fluorspar merchants in the Kentucky-Illinois field are: Rosiclare Lead & Fluorspar Mines, Rogers, Brown & Co., Cincinnati, Ohio, selling agents; Fairview Fluorspar & Lead Co., Hickman, Williams & Co., Cincinnati, Ohio, selling agents; Kentucky Fluor Spar Co., Marion, Ky.; West Kentucky Ore Co., Marion, Ky.; Reed & Wilson, Marion, Ky.; and Roberts Fluorspar Co., Marion, Ky.

Uses of Fluorspar.—Next in importance to the open-hearth steel practice of using fluorspar, in which use it plays the important rôle of limpifying the slag, and which business consumes about 75 per cent. of the production, is the iron and steel enamel industry, the manufacture of opalescent glass, the preparation of electrolyte materials for aluminium electrolytic reduction works, and the manufacture of hydrofluoric acid for the trade. Minor uses are in other fields of metallurgy, besides iron and aluminium already mentioned, and especially in the metallurgy of copper, lead and silver. It may be used advantageously in iron blast furnaces, in small amounts, for phthisic, as well as general practice for limpifying the slag, and for special iron metallurgy such as manufacture of ferro-silicon, ferro-phosphorus, etc., Finally, special arts and manufacturers make use of various fluorine compounds, the base of preparation of which is fluorspar. Manufacturers of cyanamid use fluorspar, as also do manufacturers of certain abrasives, manufacturers of carbon filaments, etc. During the year 1914, and after the European war was on and coal-tar derivatives from Germany became scarce, considerable agitation appeared in the technical press as to the manufacture in this country of sodium fluoride for a wood preservative, to take the place of other preservatives, particularly creosote.

FULLER'S EARTH

By E. H. Sellards

'he total production of fuller's earth in the United States during was 40,981 short tons, an increase over the preceding year of 2387 In addition to that produced, there was imported into the United es during the year 24,974 short tons, a substantial increase over the irts of the preceding year. Some fuller's earth is exported from United States, although the amount cannot be determined, owing ie fact that this product is not listed separately from other clays.

STATISTICS OF FULLER'S EARTH IN THE UNITED STATES
(In tons of 2000 lb.)

r.	Production.		Imports.		Years.	Production.		Imports.	
	Sh. Tons.	Value.	Sh. Tons.	Value.		Sh. Tons.	Value.	Sh. Tons.	Value.
....	20,693	$190,277	17,100	$120,670	1909.....	29,561	$289,000	12,752	$101,151
....	29,480	168,500	10,221	74,000	1910.....	30,857	277,293	16,857	132,545
....	25,745	157,776	15,181	105,997	1911.....	34,668	335,350	18,224	143,594
....	28,000	237,950	14,827	108,696	1912.....	32,715	305,522	19,109	145,337
....	34,039	323,275	14,648	122,221	1913.....	38,594	369,750	18,890	145,588
....	30,517	270,685	12,279	93,413	1914.....	40,981	403,646	24,974	195,083

lorida is the chief producer of fuller's earth in the United States, than 75 per cent. of the total production during 1914 being credited at state. The other states which contributed to the total output g 1914 were Arkansas, California, Colorado, Georgia, Massachusetts, Texas.

uller's earth is a clay which has the property of absorbing basic s and removing these from solution in animal, vegetable, and ral oils, as well as from water and certain other liquids. In com- e the earth finds its chief use in clarifying oils, although it has in ion a number of minor uses, among which are the removal of the s of coloring from water in dyeing cloth; as an ingredient in talcum lers; as a detergent in fulling cloth; and to some extent for medicinal oses, having been used in poultices for swellings, ulcers and sores. r's earth has also been used recently in the preparation of a new nt, known as Lloyd's reagent for alkaloids. This reagent, used he removal of alkaloids from the aqueous solution of their salts, is rted to be more efficient than charcoal or freshly precipitated inium, heretofore chiefly used for that purpose. The action of reagent is supposed to be due to the presence of hydrous aluminium ate.[1]

The properties of fuller's earth arise apparently from the physical

[1] *Jour. Amer. Pharm. Assn.*, pp. 625–630, May, 1914.

condition of the clay, and can be detected only by a filtering test by which its practical utility in clarifying oils is determined. Various other properties are assigned to fuller's earth, but all, aside from the actual bleaching tests, are so variable or are common to such a variety of clays as to be of only secondary value as a means of identification. Non-plasticity is often given as a property of fuller's earth, but it appears from the investigations of Porter[1] and others that some of the fuller's earths are distinctly plastic when mixed with a large proportion of water. Some of the fuller's earths will disintegrate in water, although others are little affected thereby. Most fuller's earths, on account of their porosity, when dry will adhere firmly to the tongue, but some other clays will do the same. In color, fuller's earth is as variable as other clays, and while buff and blue clays predominate, others are brown, gray, or almost white. As a rule fuller's earths are light in weight, owing to their porosity, although there are exceptions, and the specific gravity is much the same as that of other clays. These secondary properties, although of value in tracing any particular bed after this has been located, are not to be relied upon as a complete test.

The fuller's earth of Florida is used chiefly in clarifying mineral oils, although some is being prepared also for vegetable oils. The fuller's earth of southern Georgia is used for mineral oils, while that of central Georgia is used for vegetable oils. The fuller's earth of Arkansas is used chiefly in clarifying vegetable oils. The fuller's earth of Colorado is said to be used in bleaching cottonseed oil, while that of Massachusetts is reported as being used in fulling woolen goods. The fuller's earth of California, according to the State Mineralogist, is used principally as a clarifying agent in the refining of crude oils.

LIST OF FULLER'S EARTH PRODUCERS IN THE UNITED STATES

	Office.	Location of Mine.
Adams and Bemis.,		Murfreesboro, Arkansas.
American Clay Co.,		Akran, Colorado.
American Meat Packer's Assn.,	Chicago, Ill.	Fairplay, Arkansas.
American Refiner's Earth Co.,	Benton, Ark.	Klondike, Arkansas.
Argyle Fuller's Earth Co.,		Argyle, S. D.
Arizona Earth Products Co.,		Benson, Aris.
Atlantic Refining Co.,	Philadelphia, Pa.	Ellenton, Florida.
Commercial Pulverizing Co.,	Houston, Texas.	Fayette & Burleson Counties.
Eight Oil Co.,		Bakersfield, California.
Floridin Co.,	Warren, Pa.	Quincy, Florida.
Florida Fuller's Earth Co.,		Ellenton, Florida.
Fuller's Earth Co.,		Midway, Florida.
Fuller's Earth Co.,	Houston, Tex.	Somerville, Texas.
Fuller's Earth Union (Ltd.),	London, Eng.	Fairplay, Arkansas.
General Reduction Co.,	Atlanta, Ga.	Pikes Peak, Georgia.
J. E. & R. N. Farnsworth Co.,		Lancaster, Mass.
John Olsen,		Klondyke, Arkansas.
Lester Clay Co.,	Jacksonville, Fla.	Attapulgus, Georgia.
Manatee Fuller's Earth Corpn.,		Ellenton, Florida.
National Fuller's Earth Co.,		Salters Depot, S. C.
Palmetto Kaolin Co.,		South Carolina.
Somerville Development & Improvement Co.,		Somerville, Texas.
South Dakota Fuller's Earth Co.,		Rapid City, S. D.
Western Fuller's Earth Co.,		Vacaville, California.

[1] Properties and Tests of Fuller's Earth, by John T. Porter, *Bull.* 315, U. S. Geol. Surv., 268-280 (1907).

GOLD AND SILVER

By H. C. Parmelee

The value of the world's gold production in 1914 is estimated at $455,305,385, being less than that for 1913 by about $7,000,000. The amount of decrease is less than that noted in 1913, as compared with 1912, but is still an index of the declining rate of gold production. The decrease is more than accounted for by the reduced output of the Transvaal. Australia and Canada made smaller productions also, and in the last analysis Mexico and Russia will probably show a decrease. The United States increased its output of gold, but did not greatly exceed the record for 1912. Rhodesia made a substantial increase, as also did India. South American countries continued production at about the usual rate. Details of the gold production will be found in the following pages, suitably classified by countries. For obvious reasons, statistics are more meager and less satisfactory than in former years when world-wide peace prevailed.

Gold, Commerce and the War

The outstanding feature of the year was the European war, which involved most of the leading European nations. Fortunately, Europe produces less than 1 per cent. of the world's gold, so that production suffered no serious interference due to the war. On the other hand, the war emphasized the fact that the British Empire is predominant in the gold production of the world, 63 per cent. of the total output coming from British possessions, mainly the Transvaal and Australia. In order to insure continued production of this large percentage of the world's gold supply, the Bank of England arranged to advance 97 per cent. of the value of gold deposited at local banks, and adjust final settlement when the bullion could be safely consigned to London.

Trade was demoralized by the war, and in its early stages during the latter part of 1914 it appeared that gold production might suffer from a shortage of supplies such as cyanide, zinc, and machinery. This was due to the fact that Germany was the largest producer of cyanide, and that the [illegible] producing countries were dependent on this German product. [illegible] was relieved, however, by increased production in the [illegible]nd, supplemented by the release of a large ship-

ment from Germany through Holland. The closing of the Belgian zinc smelters temporarily reduced the supply of this metal in South Africa, but normal conditions were soon established by an increase in United States production.

GOLD AND SILVER PRODUCTION OF THE WORLD, 1493–1850
According to Dr. Adolph Soetbeer

Period.	Estimated Production in Kilograms.		Ratio of Silver to Gold. Weight.	Ratio of Gold to Silver. Value.	Period.	Estimated Production in Kilograms.		Ratio of Silver to Gold. Weight.	Ratio of Gold to Silver. Value.
	Gold.	Silver.				Gold.	Silver.		
1493–1520	162,400	1,316,000	8.1	10.75	1701–1720	256,400	7,112,000	27.7	15.21
1521–1544	171,840	2,164,800	12.6	11.25	1721–1740	381,600	8,624,000	22.6	15.08
1545–1560	136,160	4,985,600	36.6	11.30	1740–1760	492,200	10,662,900	21.7	14.75
1561–1580	136,800	5,990,000	43.8	11.50	1761–1780	414,100	13,054,800	31.5	14.73
1581–1600	147,600	8,378,000	56.8	11.80	1781–1800	355,800	17,581,200	49.4	15.09
1601–1620	170,400	8,458,000	49.6	12.25	1801–1810	177,780	8,941,500	50.3	15.61
1621–1640	166,000	7,872,000	47.4	14.00	1811–1820	114,450	5,407,700	47.2	15.51
1641–1660	175,400	7,326,000	41.8	14.50	1821–1830	142,160	4,605,600	32.4	15.80
1661–1680	185,200	6,740,000	36.4	15.00	1831–1840	202,890	5,964,500	29.4	15.75
1681–1700	215,300	6,838,000	31.8	14.97	1841–1850	547,590	7,804,150	14.3	15.83

GOLD PRODUCTION OF THE WORLD, 1851–1914

Year.	Value.	Year.	Value.	Year.	Value.	Year.	Value.
1851....	$67,600,000	1867...	$104,000,000	1883...	$95,400,000	1899...	$311,505,947
1852....	132,800,000	1868...	109,700,000	1884...	101,700,000	1900...	258,829,703
1853....	155,500,000	1869...	106,200,000	1885...	108,400,000	1901...	260,877,429
1854....	127,500,000	1870...	106,900,000	1886...	106,000,000	1902...	298,812,493
1855....	135,100,000	1871...	107,000,000	1887...	105,775,000	1903...	329,475,401
1856....	147,600,000	1872...	99,600,000	1888...	110,197,000	1904...	349,088,293
1857....	133,300,000	1873...	96,200,000	1889 ..	123,489,000	1905...	378,411,754
1858....	124,700,000	1874...	90,800,000	1890...	118,848,700	1906...	405,551,022
1859....	124,900,000	1875...	97,500,000	1891 ..	130,650,000	1907...	416,101,396
1860....	119,300,000	1876 ..	103,700,000	1892...	146,202,600	1908...	443,355,856
1861....	113,800,000	1877...	114,000,000	1893...	158,437,551	1909...	458,424,058
1862....	107,800,000	1878...	119,000,000	1894...	182,509,283	1910...	453,766,523
1863....	107,000,000	1879...	109,000,000	1895...	198,995,741	1911...	464,346,495
1864....	113,000,000	1880...	106,600,000	1896...	211,242,081	1912...	474,322,664
1865....	120,200,000	1881...	103,102,000	1897...	237,833,984	1913...	462,669,353
1866....	121,000,000	1882...	102,000,000	1898...	287,327,833	1914...	455,305,385

SILVER PRODUCTION OF THE WORLD, 1856–1914

Year.	Kilograms.	Year.	Kilograms.	Year.	Kilograms.	Year.	Kilograms.
1856–1860 .	4,534,950	1883....	2,746,123	1894.....	5,205,065	1905.....	5,638,183
1861–1865 .	5,505,575	1884....	2,788,727	1895.....	5,667,691	1906.....	5,683,947
1866–1870..	6,695,425	1885....	2,993,805	1896.....	5,496,178	1907.....	5,704,083
1871–1875 .	9,847,125	1886....	2,902,471	1897.....	5,663,304	1908.....	6,612,304
1876.....	2,323,729	1887....	2,990,398	1898.....	5,575,336	1909.....	7,069,656
1877.....	2,388,612	1888....	3,385,606	1899.....	5,529,024	1910.....	7,471,663
1878.....	2,551,364	1889....	3,901,809	1900.....	5,599,216	1911.....	7,906,446
1879.....	2,507,507	1890....	4,180,532	1901.....	5,438,443	1912.....	7,804,516
1880.....	2,499,998	1891....	4,479,649	1902.....	5,121,469	1913.....	(e)6,668,463
1881.....	2,592,639	1892....	4,985,855	1903.....	5,386,044	1914.....	(e)6,709,188
1882.....	2,769,065	1893....	5,339,746	1904.....	5,669,124	.....	.....

(e) Estimated. 1 kilogram = 32.15 Troy ounces.

GOLD PRODUCTION OF THE WORLD

tries.	1912.			1913.			1914.		
	Oz. Fine.	Kilo-grams.	Value.	Oz. Fine.	Kilo-grams.	Value.	Oz. Fine.	Kilo-grams.	Value.
, North:									
tates...	(b)4,437,561	138,008	$91,685,134	(b)4,299,784	133,741	$88,844,400	(b)4,492,336	139,731	$92,823,500
.....	(a)611,885	19,032	12,648,794	(a)802,973	24,976	16,598,923	(a)770,374	23,962	15,925,044
.....	(g)1,096,058	34,092	22,655,519	813,083	25,290	16,807,768	(e)879,707	27,363	18,185,000
America.	(e)175,000	5,442	3,617,250	(e)146,608	4,560	3,030,400	(e)120,938	3,761	2,500,000
, South:									
a.....	(e)14,467	450	299,043	(e)5,144	160	107,300	.....	.....	.....
.....	(a)1,117	35	23,098	(e)84,690	263	175,000	.....	.....	.....
.....	(g)129,499	4,028	2,676,950	(e)172,700	5,372	3,570,000	.....	.....	.....
.....	(a)35,397	1,101	731,715	(e)35,365	1,100	731,053	.....	.....	.....
a.....	(e)160,750	5,000	3,322,700	(e)143,768	4,475	2,971,700	.....	.....	.....
.....	(e)12,860	400	265,816	(e)19,666	610	406,500	(e)14,512	451	300,000
British..	(a)42,563	1,324	879,777	(e)42,564	1,324	879,000	.....	.....	.....
Dutch..	(a)13,948	434	288,410	(a)27,640	860	571,100	.....	.....	.....
French..	(e)144,675	4,500	2,990,430	(e)147,585	4,594	3,050,600	.....	.....	.....
.....	(a)46,135	1,435	953,687	(e)23,328	740	492,200	.....	.....	.....
.....	(e)3,215	100	66,454	(e)5,370	165	111,000	.....	.....	.....
la.....	(e)17,682	550	365,497	(e)30,164	939	623,500	.....	.....	.....
rope:									
.....	(a)6,509	202	134,543	(a)9,032	281	186,714	(e)7,256	226	150,000
.....	(e)96,442	3,000	1,993,620	(e)87,668	2,728	1,812,100	(e)70,144	2,182	1,450,000
.....	(a)91,853	2,857	1,898,771	(a)94,137	2,928	1,945,972	(e)84,656	2,633	1,750,000
y.....	(e)160,750	5,000	3,322,700	.....	.....	.....	.....	.....	.....
.....	(a)1,061	33	21,930	(a)430	13	8,886	.....	.....	.....
.....	(a)1,395,882	43,562	28,852,881	(a)1,073,972	33,430	22,199,000	(e)1,294,663	40,269	26,763,000
.....	(a)129	4	2,658	(e)111	4	2,300	.....	.....	.....
.....	(a)997	31	19,601	(a)804	25	16,620	.....	.....	.....
.....	(e)322	10	6,645	.....	.....	.....	.....	.....	.....
.....	.....	.....	.....	(e)12,148	378	251,100	.....	.....	.....
Kingdom.	.....	.....	.....	(a)1,340	40	27,800	.....	.....	.....
ica:									
.....	(e)30,237	940	$625,000	(e)98,916	3,064	2,044,600	(e)43,537	1,354	900,000
ear.....	(e)96,760	3,009	2,000,000						1,100,000
.....	(a)642,807	19,994	13,174,058	(a)689,954	21,460	14,261,343	(a)854,480	26,578	17,423,087
d.....	(a)9,131,558	283,991	188,749,317	(a)8,794,824	273,930	181,784,223	(a)8,378,139	260,595	173,189,367
ast.....	(a)342,045	10,638	7,070,071	(a)379,679	11,810	7,954,450	(e)419,510	13,049	8,404,660
la:									
British..	(e)80,375	2,500	1,661,350	.....	.....	.....	.....	.....	.....
ndia....	(a)534,768	16,634	11,054,608	(a)539,502	16,781	11,152,463	(e)596,419	18,551	12,328,975
.....	(e)160,750	5,000	3,322,700	(e)176,526	5,510	3,658,900	(e)175,360	5,454	3,625,000
, British	.....	.....	.....	(e)65,360	2,036	1,352,000	(e)226,879	7,057	4,690,000
, Dutch	(e)160,750	5,000	3,322,700	(e)163,860	5,100	3,387,100			
ns.....	.....	.....	.....	(e)3,614	110	74,700	.....	.....	.....
.....	(e)53,048	1,650	1,096,491	.....	.....	.....	.....	.....	.....
.....	(a)168,241	5,233	3,477,822	(a)216,273	6,727	4,470,723	(e)216,551	6,736	4,476,500
.....	(g)243,922	7,586	5,041,867	(e)138,006	4,296	2,852,600	(e)145,125	4,514	3,000,000
tates....	(a)12,866	400	265,940	.....	.....	.....	.....	.....	.....
.....	.....	.....	.....	(e)2,733	85	56,500	.....	.....	.....
sia.....	(a)2,636,391	81,922	54,492,402	(a)2,553,327	79,419	52,781,525	(e)2,414,674	75,106	49,915,336
ountries.	(e)25,000	778	516,750	.....	.....	.....	.....	.....	.....
.....	22,948,716	713,867	$474,322,664	(e)22,381,688	696,164	$462,669,558	(e)22,025,446	680,584	$455,305,385

Official statistics of the country. (b) United States Mint Report. (c) Six states and New Zealand.
Estimated. (g) Exports.

The shock of the European war affected the entire world of commerce and finance and produced some unprecedented conditions. On July 31 the London Stock Exchange was closed for the first time in its existence, and remained closed for 5 months. The New York Stock Exchange also was closed. Various countries declared a moratorium for extended periods. Exchange fluctuated widely early in the crisis. Messrs. Samuel Montagu & Co. point out that remittances from London to Paris commanded a premium of nearly 3 per cent. over the par of exchange, while remittances from New York to London suffered a discount of from 13 to 33 per cent. Comparing the relative gold stocks of the Bank of England and the Treasury of the United States, and the enormous fall in United States exchange in spite of the large stock of gold carried, Messrs. Montagu remark: "It is not the mere existence of huge stocks of gold, but their effective use that ensures a stable exchange in a time of crisis." They point out also that in no country was the stability of exchange so marked on the advent of war as in India. "The circulation of silver rupees to the face value of perhaps £140,000,000 has been maintained easily, within about 1⅛ per cent. of the par, notwithstanding events capable of exerting an abnormal strain."

The tremendous demand for gold by European countries resulted not only in conserving their own resources and those of their colonial possessions, but also in absorbing a large quantity from the United States. The official estimate of the value of gold exports from the United States in 1914 is $242,711,000. Imports were valued at $58,122,000. The excess of exports over imports was, therefore, about $184,589,000, as against an excess of only $28,093,778 in 1913. The gold imported in 1914 was, as usual, in ore, bullion, and coin; $35,759,000 came from Canada and the remainder chiefly from Japan, Mexico, and Central and South America. The exports, which were of especial interest in 1914, were about $113,513,000 to Canada, $92,323,000 to France, and $31,116,000 to England, and were mainly in United States coin and fine bars.

Imports of gold in India fell from £18,500,000 in 1913 to about £8,150,000 in 1914. This relates to gold in the form of sovereigns. Shipments of bar gold probably would have been maintained at a normal figure of about £8,500,000 but for the war. The price of bar gold at London went to a premium in 1914, reaching 77s. 9⅞d. on May 5, this being the highest quotation since October 16, 1909. The premium resulted from competition between France and Germany, and also from the strong demand for India, to which country a record shipment of £317,000 was made in the third week of April. The Bank of England gold reserve was about £36,671,405 on July 30; £26,041,070 on August 7; £47,051,075 on September 3, increasing to about £72,000,000 by the close of the year.

The increase during the latter part of the year was represented by deposits in Canada and South Africa for the account of the Bank of England, thus obviating risks attendant on transporting gold during the period of war.

The Silver Market

The downward tendency of silver prices noted in 1913 continued with marked effect throughout 1914. In January the average London price was 26.553d. This fell steadily through the year to an average of 22.9d. in December. The usual differential between the London and the New York markets of about 1.5 cts. per oz. prevailed until August, when it mounted to between 6 and 7 cts.

AVERAGE PRICE OF BAR SILVER IN LONDON, 1834–1914
(In pence per standard ounce, 0.925 fine)

Year.	Pence.	Year.	Pence.	Year.	Pence.	Year.	Pence.	Year.	Pence.	Year.	Pence.	Year.	Pence.
1834.	59.9375	1844	59.5000	1854	61.5000	1864	61.3750	1874	58.3125	1884	50.6250	1894	28.9375
1835.	59.6875	1845	59.2500	1855	61.3125	1865	61.0625	1875	56.8750	1885	48.6250	1895	29.8750
1836.	60.0000	1846	59.3125	1856	61.3125	1866	61.1250	1876	52.7500	1886	45.3750	1896	30.7500
1837.	59.5625	1847	59.6875	1857	61.7500	1867	60.5625	1877	54.8125	1887	44.6250	1897	27.5625
1838.	59.5000	1848	59.5000	1858	61.3125	1868	60.5000	1878	52.5625	1888	42.8750	1898	26.4375
1839.	60.3750	1849	59.7500	1859	62.0625	1869	60.4375	1879	51.2500	1889	42.6875	1899	27.4375
1840.	60.3750	1850	60.0625	1860	61.6875	1870	60.5625	1880	52.2500	1890	47.6875	1900	28.2500
1841.	60.0625	1851	61.0000	1861	60.8125	1871	60.5000	1881	51.6875	1891	45.0625	1901	27.1875
1842.	59.4375	1852	60.5000	1862	61.4375	1872	60.3125	1882	51.6250	1892	39.8125	1902	24.0900
1843.	59.1875	1853	61.5000	1863	61.3750	1873	59.2500	1883	50.5625	1893	35.6250	1903	24.7500

Year.	Jan.	Feb.	Mar.	April.	May.	June.	July.	Aug.	Sept.	Oct.	Nov.	Dec.	Year.
1904....	26.423	26.665	26.164	24.974	25.578	25.644	26.760	26.591	26.591	26.349	26.760	27.930	26.399
1905....	27.930	28.047	26.794	26.108	26.664	26.910	27.160	27.822	28.528	28.637	29.493	29.977	27.839
1906....	30.113	30.464	29.854	29.984	30.968	30.185	30.113	30.529	31.483	32.148	32.671	32.003	30.868
1907....	31.769	31.852	31.325	30.253	30.471	30.893	31.366	31.637	31.313	28.863	27.154	25.362	30.188
1908....	25.738	25.855	25.570	25.133	24.377	24.760	24.514	23.858	23.877	23.725	22.933	22.493	24.402
1909....	23.843	23.706	23.227	23.708	24.343	24.166	23.519	23.588	23.743	23.502	23.351	24.030	23.706
1910....	24.154	23.794	23.690	24.483	24.797	24.651	25.034	24.428	24.567	25.596	25.680	25.160	24.670
1911 ...	24.865	24.081	24.324	24.595	24.583	24.486	24.286	24.082	24.209	25.594	25.649	25.349	24.592
1912....	25.887	27.190	26.875	27.284	28.038	28.215	27.919	28.375	29.088	29.299	29.012	29.320	28.842
1913....	28.993	28.356	26.669	27.415	27.794	27.195	27.074	27.335	27.985	28.083	27.262	26.720	27.573
1914....	26.553	26.573	26.788	26.958	26.704	25.948	25.219	25.979	24.260	23.199	22.703	22.900	25.313

AVERAGE PRICE OF SILVER IN NEW YORK
(In cents per fine ounce)

Year.	Jan.	Feb.	Mar.	April.	May.	June.	July.	Aug.	Sept.	Oct.	Nov.	Dec.	Year.
1905....	60.690	61.023	58.046	56.600	57.832	58.428	58.915	60.259	61.695	62.034	63.849	64.850	60.352
1906....	65.288	66.108	64.597	64.765	66.976	65.394	65.105	65.949	67.927	69.523	70.813	69.050	66.791
1907....	68.673	68.835	67.579	65.462	65.981	67.090	68.144	68.745	67.792	62.435	58.677	54.565	65.327
1908....	55.678	56.000	55.365	54.505	52.795	53.663	53.115	51.683	51.720	51.431	49.647	48.769	52.864
1909....	51.750	51.472	50.468	51.428	52.905	52.538	51.043	51.125	51.440	50.923	50.703	52.226	51.502
1910....	52.375	51.534	51.454	53.221	53.870	53.462	54.150	52.912	53.295	55.490	55.635	54.428	53.486
1911....	53.795	52.222	52.745	53.325	53.308	53.043	52.630	52.171	52.440	53.340	55.719	54.905	53.304
1912....	56.260	59.043	58.375	59.207	60.880	61.290	60.654	61.606	63.078	63.471	62.792	63.365	60.835
1913....	62.938	61.642	57.870	59.490	60.361	58.990	58.721	59.293	60.640	60.793	58.995	57.760	57.791
1914....	57.572	57.506	58.067	58.519	58.175	56.471	54.678	54.344	53.290	50.654	49.082	49.375	54.811

SILVER PRODUCTION OF THE WORLD

Country.	1913.			1914.		
	Oz. Fine.	Kilograms.	Value. (d)	Oz. Fine.	Kilograms.	Value. (d)
North America:						
United States	(b)66,801,500	2,077,807	$38,611,267	(b)67,929,700	2,112,899	$37,232,948
Canada	(a)31,845,803	990,538	19,040,924	(a)27,544,231	856,741	15,097,269
Mexico	(g)49,461,103	1,538,448	33,330,345			
Central America						
South America:						
Argentina						
Bolivia						
Chile						
Colombia						
Ecuador						
Peru						
Europe:						
Austria	(a)1,750,053	54,434	1,068,778			
Belgium (f)	(a)8,164,171	253,940	4,718,891			
France	(c)1,511,050	47,000	873,387			
Germany	(e)17,293,485	537,900	9,995,634			
Greece						
Hungary	(a)279,576	8,696	161,595			
Italy	(a)420,972	13,094	243,322			
Norway	(e)271,957	8,549	157,191			
Portugal						
Russia						
Spain						
Sweden	(a)33,340	1,037	19,271			
Turkey						
United Kingdom	(e)457,135	14,240	274,220			
Asia:						
Dutch Indies						
Formosa						
Japan	(e)4,787,135	148,900	2,766,964	(e)4,647,767	144,565	2,547,488
Africa						
Australasia	(e)18,854,870	586,466	10,898,115			
Other countries						
Total	(e)214,391,085	6,668,463	$123,918,047	(e)215,700,394	6,709,188	$118,227,543

(a) Official statistics of the country. (b) United States Mint Report. (e) Estimated. (d) The value of silver unless specifically reported in the official statistics of the country is taken as $0.578 in 1913 and $0.548 in 1914. (London quotations.) (f) Largely from imported ores and may duplicate production to some extent. (g) Exports.

Early in the year a London syndicate that had taken over the stock of the India Specie Bank, which became insolvent in 1913, began gradually to liquidate the surplus, and by April had closed out its holdings of silver. This greatly reduced the available stock of silver in London and the East, and gave a firmer tone to the market. The internal troubles of Mexico also served to curtail production, and the loss of $2,000,000 worth of silver which went down with the "Empress of Ireland" further affected the supply. Under these bullish influences the market reached its highest point for the year in April, when the average London price was 26.958d. and the average New York price 58.519 cts. The demand from China and India, however, proved disappointingly light, and about the middle of the year prices began to sag and declined steadily to 22.9d. (London) and 49.375 cts. (New York) in December, being the lowest since 1911. Quotations were suspended August 1 for nearly 10 days at the outbreak of the war. This condition threatened to work a serious hardship on United States producers of silver, and steps were immediately taken to

induce the U. S. Mint to buy silver. On August 8 the London price was set nominally at 26d., and on August 11 the Mint arranged to buy 1,175,000 oz. at 52 cts. This relieved the situation materially, and further improvement came with better conditions as to ocean shipping and foreign exchange. The entire year, however, was a difficult one for producers of silver.

United States imports of silver in 1914 were valued at $25,331,000, as estimated from the records of the Bureau of Domestic and Foreign Commerce. The exports were valued at $50,500,000, or $25,169,000 in excess of the imports. In 1913 the excess of exports over imports was $26,908,812.

The imports of silver in 1914 were, as usual, chiefly in ore and bullion and mainly from Mexico, which supplied $14,186,000 in silver, and Canada, which supplied $5,657,000.

Gold and Silver Mining in the United States

The gold-mining industry of the United States was prosperous during 1914, according to H. D. McCaskey of the U. S. Geological Survey. The preliminary figures issued by the Geological Survey and the Bureau of the Mint show gold production valued at $92,823,500, which in round numbers is $4,000,000 greater than in 1913 and $1,000,000 greater than in 1912. The increase comes from Alaska, Arizona, California, Colorado, Montana and New Mexico. California retains its first rank, followed in order by Colorado, Alaska, Nevada and South Dakota, as in 1913. The Philippine production has increased steadily and passed the $1,000,000 mark in 1914.

Increased gold production on a large scale can hardly be expected from any of the states, judging from the present outlook. The low-grade deposits in the Juneau district, which began production late in 1914 and early in 1915, may increase our total output, but aside from this new discoveries must be depended upon. Hence, the future domestic production of gold may show a decline.

American mining companies that publicly announce their dividends paid $55,563,732 in 1914, compared with $73,440,701 in 1913. Canadian and Mexican companies paid $15,058,220 in 1914 and $21,654,260 in 1913, according to the *Engineering and Mining Journal*. United States metallurgical and holding companies connected with the mining industry paid $91,782,505 in 1914, as compared with $99,740,693 in 1913. The notable decreases are ascribed to the European war and the revolutions in Mexico. The figures do not pertain strictly to gold and silver mining companies, but the production of precious metals contributes largely to the total.

Preliminary figures on the silver production of the United States in 1914 show 67,929,700 fine ounces, as compared with 66,801,500 fine ounces produced in 1913. The increase would have been much greater but for curtailment on account of the war.

PRODUCTION OF GOLD IN THE UNITED STATES (a)

States.	1911.		1912.		1913.		1914.	
	Fine Ounces.	Value. (b)	Fine Ounces.	Value. (b)	Fine Ounces.	Value. (b)	Fine Ounces.	Value. (b)
Alabama	890	$18,400	855	$178,674	443	$9,200	590	$12,200
Alaska	806,179	16,665,200	842,108	1,739,943	735,364	15,201,300	766,744	15,850,800
Arizona	170,348	3,521,400	159,890	3,303,504	198,406	4,101,400	218,113	4,508,800
California	964,041	19,928,500	967,443	19,988,486	979,174	20,241,300	1,037,537	21,447,800
Colorado	925,839	19,138,800	909,519	18,791,710	876,057	18,109,700	961,748	19,881,100
Georgia	1,548	32,000	478	9,881	645	13,300	552	11,400
Idaho	65,688	1,357,900	63,110	1,303,917	60,193	1,244,300	51,568	1,066,000
Montana	176,554	3,649,700	156,589	3,235,287	160,647	3,320,900	190,361	3,935,100
Nevada	875,438	18,096,900	645,253	13,331,680	579,408	11,977,400	532,309	11,003,800
New Mexico	36,847	761,700	29,280	604,961	43,149	892,000	58,418	1,207,600
North Carolina	3,478	71,900	6,910	142,760	5,574	115,200	5,752	118,900
Oregon	30,679	634,200	30,531	630,801	71,495	1,477,900	77,134	1,594,500
South Carolina	972	20,100	754	15,587	198	4,100	295	6,100
South Dakota	359,402	7,429,500	377,311	7,795,680	348,988	7,214,200	355,621	7,310,000
Tennessee	576	11,900	478	9,881	371	7,700	285	5,900
Texas	189	3,900	492	10,170	11	200	498	10,300
Utah	217,020	4,486,200	211,845	4,376,971	172,711	3,570,300	153,842	3,180,200
Virginia	150	3,100	424	8,755	11	200	48	1,000
Washington	40,635	840,000	13,796	285,044	31,806	657,500	29,383	607,400
Wyoming	1,030	21,300	1,108	22,884	847	17,500	106	2,200
Other States	5	100	15	310	32	700	.....	.....
Total	4,677,508	$96,692,700	4,418,139	$91,284,886	4,265,530	$88,176,300	4,440,904	$91,760,300
Porto Rico	97	2,000	.....	.....	50	1,100	150	3,100
Philippine Islands	9,448	195,300	19,372	400,248	34,204	707,000	51,282	1,060,100
Total	4,687,053	$96,890,000	4,437,561	$91,685,134	4,299,784	$88,884,400	4,492,336	$92,823,500

(a) The statistics in this table are reported by the Director of the Mint, those for 1914 being the preliminary figures (subject to revision). (b) At $20.67 per oz.

Alabama.—The gold-mining industry of Alabama is of comparatively minor importance, but in the opinion of some competent engineers there are a number of deposits of gold ore that probably will be worked at a profit in the future. Heretofore gold has been won mainly from placer deposits that were worked in a crude and extravagant manner. The lode deposits, however, are not of a refractory nature and can be treated by well-known processes. Gold is found in quartz veins and in some of the pyritic deposits. At depth, where the pyrite is unaltered, the ore is still gold-bearing but does not yield the precious metal to ordinary amalgamation. Cyanidation has been shown to be successful. If an average value of from $2 to $3 per ton can be maintained, the large ore bodies can be worked profitably. The output of gold in 1914 is estimated at 590 fine oz., and of silver, 100 oz.

Alaska.—The preliminary figures on gold output of this Territory for 1914, according to Alfred H. Brooks of the U. S. Geological Survey,

show production valued at $15,900,000, as against $15,626,813 in 1913. The value of silver production was $191,000 in 1914 and $218,988 in 1913. The gold-mining industry had a prosperous season, and the prospect for continued prosperity is excellent owing to the anticipated new production for which preparation was made during 1914.

Mining began in Alaska in 1880, and since that time the total value of gold production has been $244,300,000. The value of silver output has aggregated $2,251,000.

The route of the Government's Alaskan railroad is from Seward, on Resurrection Bay, to Fairbanks, on the Tanana River. A branch line will be built into the Matanuska coal fields. The distance by rail between Seward and Fairbanks will be 471 miles. Coal fields at Matanuska and Nenana will be opened, and are expected to aid materially in developing the industries of Alaska. It is expected that about 40 miles of the road will be completed in 1915.

Placer Mining.—The value of placer gold produced in 1914 was estimated at $10,700,000, being practically the same as in 1913. Dredges in operation numbered 44, and their production is valued at from $2,050,000 to $2,300,000. Increased production made in the Ruby, Seward Peninsula, Iditarod, and Hot Springs districts offsets the decline in output from Fairbanks district and other camps.

In the Fairbanks district there was a decrease in production amounting to about $500,000, the output being estimated at about $3,000,000. Most of the production came from drift mines. Power-scraper plants increased in number, about 15 being in operation. This method of mining promises to become important, costs running only about half as much per sq. ft. as in drift mining. General improvement in this district is not looked for until the government railroad is in operation.

The Seward Peninsula had a good year. Production increased, amounting to between $2,700,000 and $3,000,000. Several new dredges were built, the total number being 41; of these 11 are in the Nome district, 10 in the Council, 9 in the Solomon, 5 in the Teller, 4 in the Kougarok, and 2 in the Candle and Inmachuck. Water was abundant and all companies, large and small, had a good season. Some of the dredges, however, operated at a loss, as heretofore.

The Innoko-Iditarod region yielded probably $2,200,000 in 1914. Two dredges were in operation, one each on Flat Creek and Otter Creek. The entire region experienced a good year.

The Ruby made a production of about $1,000,000, showing an increase of about 75 per cent. over 1913. This district is regarded as one of the most promising of the interior camps, and one that will rapidly forge ahead when better conditions of transportation prevail.

Of the upper Yukon districts, Hot Springs had the best season in its history, producing probably about $1,000,000. Most of the production came from the deep ground on lower Sullivan Creek, which has been drilled extensively during the past 2 years. The production of the Circle district was about $200,000, mainly from hydraulic operations, for which there was an abundance of water. The Koyukuk production was greater than in 1913, and amounted to about $280,000. Chisana continued as a steady producer and turned out about $250,000, chiefly from Bonanza Creek. New discoveries were made during the year at the head of the Tolovana River and in the Healy River drainage.

The report of the Mine Inspector for the Territory of Alaska for the fiscal year ended June 30, 1914, contains much information regarding the different properties coming within the control of the Inspector. The report covers in detail many economic features of mining, such as labor conditions, cost data and transportation charges.

Lode Mining.—About 26 gold-lode mines were operated during 1914, producing gold to the value of roundly $5,100,000. In the Fairbanks district quartz mining was not particularly successful, as the abundance of water hindered open-cut work. The Rhoads-Hall quartz mill was the only one of 15 to operate continuously. The Willis ran intermittently on custom ore until it was purchased by Crites and Feldman and installed on their property, where it commenced operations in September. Crites and Feldman have added a compressor and drills to their equipment and promise to become steady producers. The district has been overcrowded with men, the population being about 4000.

In the vicinity of Prince William Sound five gold-lode mines were operated. Near Valdez two mills were installed on the Ramsey and the Big Four properties. The Mountain King milled a small tonnage and the Cliff was operated during the first half of the year. On the Kenai Peninsula the Skeen-Lechner and the Palmer Creek mills operated part of the season.

Juneau.—The most important and far-reaching developments of the year were in the Juneau district, where the Alaska-Gastineau, Alaska-Juneau, and Ebner properties were under development. It is to the production of these properties, and possibly to others in the vicinity, that the United States will look for an immediate increase in gold production. Both mining and milling operations are laid out on a large scale, and when operations are well under way Juneau and Treadwell together will comprise one of the important gold-producing districts of the world.

The Alaska-Gastineau was ready for production toward the last of 1914. Late information from this property indicates that the ore being milled from widely different points is averaging nearly $2 per ton in value.

The mill probably will have a capacity of 10,000 tons per day when finally adjusted. The Sheep Creek tunnel and the Salmon Creek dam were completed during 1914. The dam is 165 ft. high and 720 ft. long and holds 19,000 acre-ft. of water. Development work done during the year greatly increased the ore reserves. The surface and underground equipment at this property is reported to be a model of convenience and efficiency. The general type of ore treatment is in many respects similar to that adopted by the porphyry copper companies of the western states, and considerable interest attaches to the outcome of a radical departure in the treatment of gold ore.

At the Alaska-Juneau a great amount of development work was done. The mill site was cleared and buildings were erected, and the first 50 stamp unit installed. This property should come into full production during 1915 and materially affect the gold production of the Territory.

The Ebner property, under development by the United States Smelting, Refining & Mining Co., is not as near the production point as the two properties just mentioned. The ore-body has been developed by a cross-cut tunnel and considerable ore testing has been done in an experimental mill.

The Jualin Alaska Mines Co., with claims on the north shore of Berner's Bay, was prevented from prosecuting its plans on account of the war. The company was financed in France and Belgium, and $450,000 has been spent on equipment for mining. It is reported that bids for erection of a mill of 1000 tons daily capacity were asked for just prior to the outbreak of the war.

The Treadwell properties, across Gastineau channel from Juneau, operated steadily throughout the year. Thirty stamps were added to the Seven-Hundred mill and the 300-stamp mill was electrified. A central shaft and crushing plant was started to handle the ore from the Treadwell, Seven-Hundred, and Mexican mines at the rate of about 4000 tons per day. Underground development included the connection of this shaft with the lower levels of the three mines.

A series of articles on mining in the Far North appeared in the *Mining and Scientific Press*, written by Emil E. Hurja. This series gives a wealth of detailed information regarding general conditions and the operation of individual properties.

Arizona.—According to Victor C. Heikes of the U. S. Geological Survey, the mine yield of gold in Arizona increased from $4,023,911 in 1913 to about $4,570,000 in 1914. This increase of nearly 14 per cent. was almost entirely in siliceous ores of gold and silver mines. The Tom Reed, Gold Road, Vulture, and Commonwealth mines produced more than half the total gold of the State, the remainder coming chiefly from copper

ores. Increases were made at both the Tom Reed and Gold Road mines, and a notable quantity came from the silver ores cyanided at the Commonwealth property. Several new gold mills were built, one at the Goldfield mine in Pinal County and several in Yavapai County.

A record production of silver was made in Arizona in 1914, notwithstanding the reduced market price. The output increased from 3,948,091 oz. in 1913 to about 4,469,000 oz. in 1914. The increase of over 13 per cent. resulted from the treatment of more siliceous silver ore. Most of the silver came from copper ores, and most of the remainder from siliceous ores and lead ore. At Pearce, in Cochise County, the Commonwealth mill was treating by the cyanide process about 300 tons of silver ore a day.

The Bureau of the Mint estimates 1914 gold production at 218,113 fine oz.; the silver production is estimated at 4,306,600 oz.

The annual report of the Tom Reed Gold Mines Co., at Oatman, Ariz., for the year ended April 1, 1914, shows a net gain of $629,981. The gross recovery from 48,100 tons of ore treated was $1,146,053, and from scraps, $12,874; total gross bullion production, $1,158,927. Other income brought the gross amount up to $1,166,906 before deducting operating expenses. The total charges amounted to $536,925, distributed as follows: production expenses, $296,863; general, administration and taxes, $60,824; depreciation of plant and mining claims, $174,198; extraordinary charges, $5040. The total cost per ton was $8.662, consisting of mining, $4.153; milling, $1.664; cyaniding, $1.557; marketing, $0.155; depreciation, $1.133. Dividends for the year amounted to $618,497; the balance in current assets was $147,621. Mine development totaled 5695 ft., of which 465 ft. was shaft sinking. Development work was reported farther ahead of stoping than at any other time.

The Frisco mine was inactive most of the year. An important development was reported from the Arabian mine, about 12 miles from Kingman, where the Mines Company of America carried on successful development work during the year. The Gold Road mine operated as usual, producing 107,846 tons of ore. Development work disclosed profitable ore, generally of low grade. The Vulture Mines Co. operated steadily, employing about 200 men. This company milled 35,000 tons of ore yielding $16 per ton, representing a recovery of from 88 to 90 per cent.

At Pearce the Commonwealth Mining and Milling Co. operated continuously, with the exception of about 2 weeks in August, when it was unable to market its silver bullion. The monthly production amounted to about 60,000 oz. from 9000 to 9500 tons of ore.

A large quantity of gold and silver produced in Arizona comes from

ores produced by companies engaged primarily in copper mining. Thus the Copper Queen produced 15,769 oz. gold and 1,036,672 oz. silver, and the Calumet and Arizona added 24,122 oz. gold and 922,143 oz. silver.

California.—According to preliminary figures compiled by Charles G. Yale of the U. S. Geological Survey, the gold production of California for 1914 was valued at $21,138,500, while the silver output amounted to 1,987,700 oz. The Bureau of the Mint estimates a gold production of 1,037,537 fine oz., valued at $21,447,800, and a silver output of 1,744,500 fine oz. The 1913 production of gold was valued at $20,406,958, and the silver output was 1,378,399 fine oz. California contains about 800 producing mines, divided about equally between lode and placer properties. The capacity of the milling plants is about 2,000,000 tons a year, the material treated having an average gold and silver value of $5.61 per ton. The state holds the premier position as a gold producer among the United States.

In placer-mining operations the dredging industry is by far the most important in the production of gold, producing about 40 per cent. of the total gold yield of the state and about 92 per cent. of the placer gold output. The principal gold-dredging fields of the state are at Oroville, Butte County; Folsom, Sacramento County; and Marysville, Yuba County, but dredges are also producing in Calaveras, Merced, Siskiyou, Stanislaus, Placer, and Trinity Counties. A few new machines have been built and much prospecting of dredging ground has been in progress. In some of the older dredging fields there has been a natural falling off in gold product, owing to exhaustion of the ground, but little general reduction of yield in the industry has been apparent in 1914. The hydraulic placers of the state, formerly so important in gold yield, now produce only about 3.73 per cent. of the total; the drift mines, 2.18 per cent.; and the surface or sluicing mines, 2.53 per cent.

Plans for a revival of hydraulic mining occupied attention during the year, and were the subject of an article in the *Mining and Scientific Press* by C. S. Haley. Arrangements were made for the construction of dams under the direction of the U. S. Bureau of Mines, the funds to be provided by a tonnage tax.

The Northern California Mining Co. was denied the privilege of operating a gold dredge within the town of Oroville, although it offered to reclaim a certain amount of ground and make it into a park for the town. The State Anti-débris Association filed suit against the Pennsylvania Dredging Co. for dumping tailings in the Feather River. Other similar suits were filed against other companies. The decisions were generally fair and equitable.

The following is an abstract of the report of the Oroville Dredging Co.,

San Francisco, Cal., for the year ended July 31, 1914. A total of 2,897,557 cu. yd. of material was excavated. Total expenditures were $143,152, of which $117,246 was for operations. Net bullion returns were $251,599, and miscellaneous earnings, $8357; total receipts, $259,956, making a net profit of $116,804 before charging depreciation on capital accounts. Balance to surplus after all charges was $73,903. The accompanying table of costs, which covers only operating expenses, shows a cost of 4.04 cts. To this must be added 0.9 ct. for expenses not charged to operations and about 1.8 cts. for charges at San Francisco and depreciation charged for dismantlement of dredges. This makes a total of about 6.74 cts. per cu. yd. A dividend of $87,242 was paid during the year and another of like amount after the close of the financial year.

OPERATING COSTS OF OROVILLE DREDGING, LTD., PER CU. YD.

Dredges.	Boston 4.	Exploration No. 2.	Exploration No. 3.	Total and Average.
Total dredging time	7,538 hr.	3,578 hr.	7,529 hr.	18,645 hr.
Cu. yd. excavated	1,217,957	340,387	1,339,213	2,897,557
Average depth, ft.	30.5	31.5	30.2	30.5
Labor and material	1.31	1.6	1.07	1.25
Electric power	0.79	0.90	0.67	0.75
Water	0.07	0.11	0.07	0.08
Repairs	1.43	0.92	0.75	1.06
Smelting and express	0.03	0.05	0.03	0.03
General expenses	0.62	1.17	0.56	0.66
Taxes and insurance	0.30	0.24	0.19	0.21
Total operating	4.55	4.99	3.34	4.04
Average daily yardage	3,336	1,967	3,641	3,208
Actual dredging time, hr. and min. daily.	20.39	20.41	20.37	20.38
Acres dredged, year	24.70	6.70	27.40	58.80
Bullion returns	8.58	12.79	7.72	8.68
Net revenue, operating	4.03	7.80	4.38	4.64
Average cu. yd. per acre	49,279			
Average yield per acre	$4,278			
Average operating expenses per acre	$1,994			

The Mother Lode region was the scene of activity that resulted in addition of new machinery and milling plants. The Keystone installed a stamp mill; the Melones a cyanide plant; the Plymouth Consolidated a modern equipment of stamps and tube mills. The output and costs at the Plymouth mine for the month of December, 1914, were estimated as follows:

		Per Ton.
Tons of ore crushed	10,200	
Value of gold	$42,330	$4.15
Working expenditure	22,618	2.21
Development charges	5,051	0.49
Surplus over above expenses	14,660	1.45
Other capital expenditure	16,283	1.60

The apex suit of the Kennedy Extension Gold Mining Co. against the Argonaut Mining Co. was decided in favor of the latter in June, 1914.

Tailings disposal along the Mother Lode was accomplished mainly by the flue method, although the Kennedy Mining and Milling Co. adopted a system using tailing wheels and impounding dam.

The Dutch and the Sweeney mines were sold during the year to New York interests, with W. G. Devereaux, manager of the Melones, as president. Other sales of property were deferred owing to a tightening of money at the outbreak of the European war.

The annual report of the Original Amador Consolidated Mines Co. for 1914 shows a total development of 5613 ft. Production amounted to 44,416 tons of an average gross value of $4.03 per ton. The average value recovered was $3.62. The cost of mining and milling was reduced from $1.40 in 1913 to $1.10 in 1914. It is anticipated that these figures can be further reduced when the large milling plant is completed and in operation. The development work of the year resulted in the creation of ore reserves that justified the erection of a milling plant of 300 tons daily capacity. In order to take care of mine débris, the company purchased a large ranch on Amador Creek and built a dam across the cañon. This is expected to take care of tailings for all time to come, and will relieve the company from unreasonable demands on the part of farmers. The financial report shows production of bullion valued at $89,551 and of concentrates valued at $32,888. Discounts bring the total profit up to $122,717 Total expenses for development, mining and milling were $105,729, leaving an operating profit of $16,988.

The report of the Brunswick Consolidated Gold Mining Co., Grass Valley, Cal., for the year ended Jan. 15, 1915, states that the results for 1914 were better than for any previous year. Production was 16,237 tons of ore, yielding an average value of $17.76 per ton. The net realization was $122,435. Dividends aggregated $94,868. Average extraction in the mill was 93.9 per cent. and average milling cost was 92.6 cts. per ton, including 34 cts. for freight and treatment of bullion and concentrates. Concentrates produced amounted to 288 tons and the cost of treatment, including an 8 per cent. loss in value, was $16.61 per ton. It is estimated that a saving of $9 per ton could be made by cyaniding these concentrates, and it is proposed to erect a $5000 plant for that purpose. Stamp duty was 0.0965 tons per hr.; quicksilver fed to the batteries amounted to 14,756 oz., or about 1 oz. per 1.1 tons of ore. Total cost of operations per ton was $10.221, divided as follows: mining, $6.053; milling, $0.926; new shaft, $1.359; repairs, $0.181; improvements, $0.408; general, $1.294.

The situation with reference to damage to agricultural crops by smelter smoke was somewhat cleared by the report of the Selby Smelter Commission, which reported favorably to the smelter, stating that the company was observing the terms of the court decree under which operation was permitted.

According to J. D. Hubbard, in the *Mining Press*, more attention has

of late been paid to drift mining. In his opinion, more than three times the amount of gold already produced (from the ancient river channels) remains locked up in these treasure houses below the lava cap. California has produced to date in gold approximately $1,600,000,000; or one-seventh of all the gold won in the world since 1492 has been mined in California since 1848.

The cost of drift mining varies greatly according to the conditions. At the Mayflower mine in Placer County, according to F. Chappellet, mining cost is $1.19 per ton and milling with steam power 25 cts. per ton, or a total of $1.44 per ton. This was in cemented gravel and more expensive to mine and treat. At the Big Dipper mine, the same class as the Mayflower, according to G. B. Hobson, the total cost was $1.85 per ton. At the Hidden Treasure mine, where the gravel is not milled and the work is done on a large scale, the cost per ton is as low as 92 cts. At the Mineral Slide mine, near Magalia in Butte County, where the face is blasted down and then the gravel hydraulicked out by water under pressure, the cost is as low as 65 cts. per ton. This is about the lowest figure recorded. At the Nugget mine at Toadtown, in Butte County, where an incline was run under the lava cap and all gravel hoisted and water pumped, the total cost was $1.37 per ton, increasing to $1.73 per ton as further depth was gained. This shows that under unfavorable conditions drift mining is profitable. The gravel in the Nugget mine averaged $6 per ton (or yard) for 110 ft., and $3.08 per ton for 496 ft. Some of the gravel went as high as $50 per ton. The gravel in the Nugget mine is all free washing, no cement gravel being found. The following details of costs for an average month at this mine may be of interest:

Tons of gravel mined	604	573
Dynamite	$33.60	$80.96
Fuse	5.64	11.30
Detonators	3.06	4.92
Rails	14.00	16.00
Ties	2.16	0.88
Lagging	1.92	0.96
Timber	2.67	1.80
Candles	3.45	5.27
Power and lights	22.64	22.00
Oil	1.20	1.05
Air pipe	4.60	4.80
Water pipe	5.40	6.00
Wire and lamps	1.30	1.45
Labor	479.25	593.75
Superintendence	150.00	150.00
Depreciation at 5 per cent	100.00	100.00
Total	$830.89	$1001.14
Per ton	1.374	1.735[1]

Colorado.—The gold production of Colorado in 1914, as estimated by the Bureau of the Mint and the U. S. Geological Survey, was 961,748 fine oz., valued at $19,881,100. The silver production is estimated at 8,612,900 fine oz. These figures compare favorably with those for 1913,

[1] Month of highest cost.

when the gold production was 876,057 fine oz., valued at $18,109,700, and the silver output 9,325,255 fine oz. The gold production showed a good increase, but there was a falling off in silver.

The smelting industry continued in about the same condition as in 1913, with plants operated at Denver (Globe), Pueblo, Leadville (Arkansas Valley), and Durango by the American Smelting & Refining Co., another at Salida by the Ohio & Colorado Smelting & Refining Co., and a matting furnace at Ouray. The products of the Colorado plants of the American Smelting & Refining Co. are shown in the following table:

Source of Ore.	Ore, Tons.	Gold, Oz.	Silver, Oz.
British Columbia	5,349	171	166,962
Colorado[1]	573,009	304,723	7,258,427
Canada	4,128	.....	2,417,419
Idaho	80,142	.....	2,816,849
Montana	558	34	26,598
New Mexico	147	767	227
South Dakota	524	979	865
Utah	1,364	10	1,545
Total	665,221	306,684	12,688,892

The outstanding feature in the gold-mining industry of the state was the production of the Cripple Creek district and the discovery of a bonanza of extremely high grade ore in the Cresson mine. The output of the Cripple Creek district, according to Charles W. Henderson of the U. S. Geological Survey, was $12,048,000, an increase of $1,143,000 over 1913. This is the largest production for any one year since 1908.

The discovery at the Cresson mine was made about November 25, 1914, on the twelfth level, at a depth of 1265 ft. below the surface. The incident is regarded as of great importance to the Cripple Creek district as a whole, indicating as it does the possibility of finding at great depths the rich ore that characterized many of the mines on their upper levels. The following description of the occurrence is taken from a report by Harry J. Wolf, Professor of Mining at the Colorado School of Mines, who visited the Cresson mine shortly after the discovery.

"A chute which was being driven from one of the cross-cuts in the ore body on this level broke into the side of a pear-shaped chamber about 14 ft. wide, 23 ft. long and 36 ft. high. This chamber was found to be about two-thirds full of loose material, and very much resembled a stope filled with broken ore.

"The filling consisted of fragments of breccia, encrusted with quartz and strontianite crystals and more or less cemented together, most of which could be mined with a pick. The incrustations were thickly sprinkled with tabular crystals of sylvanite and calaverite, some of which

[1] This includes ore shipped to other of the company's plants outside of Colorado.

were more than three-quarters of an inch long, and many of them presented a face having an area of half a square inch. The breccia itself was permeated with sylvanite crystals.

"The filling included several irregular deposits of white, crumbly material, probably strontianite, thickly impregnated with crystals of sylvanite. This material was the richest ore found, and assayed from $10,000 to $16,000 a ton. Such material, together with fragments of ore having prominent incrustations of telluride minerals, was carefully sacked in the stope. The balance of the ore was shoveled over a 1-in. screen, the fines from which assayed about $5000 to $6000 a ton, and the oversize had a value varying from $1000 to $1500 a ton.

"At the time of my visit the material in sacks might be conservatively estimated to have a net value of about $250,000. The ore remaining in the chamber and around the walls thereof could be safely estimated at another $250,000. The total profit in sight, therefore, amounted to not less than $500,000."

The Roosevelt tunnel continued to lower the water level gradually throughout the year, except in the Vindicator and Golden Cycle mines, where electric pumps are employed. In July, 1914, arrangements were made for continuing the tunnel to the Vindicator-Golden Cycle territory, and since that time the tunnel has been advanced about 6 ft. per day.

The Golden Cycle and Portland cyanide mills at Colorado Springs and the Portland, Stratton's Independence, Ajax and other local mills in the Cripple Creek district continued operations without interruption.

The Leadville district maintained its production at a good rate. The value of the gold output is estimated at $1,554,000, and the silver production at 3,860,000 oz. of silver. The corresponding figures for 1913 are $1,023,631 in gold and 3,400,318 oz. silver.

Conditions in the San Juan were rather dull and production showed a decline. The value of gold production is estimated at $3,721,000 and the silver output at 2,470,000 oz. In 1913 the gold production was valued at $4,071,683 and the silver output was 2,769,077 oz. Ouray County showed an increase in production on account of the operations at the Camp Bird mine and the Wanakah mill and matte smelter. The Tomboy had a good year and the Liberty Bell continued to be a large factor in the prosperity of the district. The prospects of the Smuggler-Union were not bright on account of the decreasing grade of the ore.

Considerable activity was noted in the Clear Creek district, but in Gilpin County mining was inactive. Boulder County showed an increased gold production, but the Creede district showed a decrease.

The year was favorable for dredging operations as far as weather was concerned, and a good season was experienced generally. The dredges

of the Tonopah Mining Co. at Breckenridge operated steadily. The output of gold bullion from the dredges and pocket mines of Summit County was estimated at $665,000, an increase of $230,000 over 1913. The dredge at Tin Cup is reported not to have yielded the returns hoped for by its promoters. This dredge replaced its gold-saving tables with Richards pulsator riffles, an adaptation of the pulsator classifier principle, but results of its operation are not known.

A matter of economic importance to Colorado mining companies was the reversal by the state Supreme Court of a former ruling regarding the "gross value" of ore for taxation purposes. The former ruling made the gross assay value the basis for taxation, but on reversal the "gross value" was held to mean the gross sum actually received for the metal content at the mine.

The report of the Tomboy Gold Mines Co., Telluride, for the year ended June 30, 1914, shows a profit of $409,541 on operations and a net balance of $343,974 after deducting London expenses, depreciation and income tax. Of this balance, $301,320 was paid in dividends. Production amounted to 137,456 tons of ore yielding $6.98 per ton. Cost of operating was $4.40 per ton, as follows: mining, $1.71; development, $0.79; milling, $0.54; concentrating, including transportation to railroad, $0.73; water, $0.13; assay office, $0.04; general, $0.24; taxes and insurance, $0.22. Experiments demonstrated that the ore was amenable to cyanidation, and a plant was erected having a capacity of 400 tons of tailings a day.

Development work at the property of the Portland Gold Mining Co. in the Cripple Creek district in 1914 totaled 15,592 ft., of which 2843 ft. was done by lessees on the 200-ft. level. Drifts cost $6.617, crosscuts $6.99, rises and winzes $7.77, No. 1 shaft $62.83, and No. 2 shaft $50.78 per ft. Shaft sinking includes timbering, pipes, guides, wiring, and everything ready for use. On the 1700-ft. level, No. 1 vein has been exposed for 1350 ft., of which 1050 ft. is shipping ore, the remainder suitable for the Victor or local mill. A large amount of prospecting is under way on this level, but a year is required to finish it. Mechanical haulage was started here in October, a 3½-ton storage-battery locomotive being used. Tramming costs have been reduced. A 515-man capacity change house was completed in December for all employees. It is thoroughly modern.

There was 62,997 tons of ore sent to the Colorado Springs mill which yielded $1,467,005, including 9955 tons worth $224,952 from lessees. The Victor mill treated 210,132 tons, 18,934 tons coming direct from the mine and 191,198 tons the reject of shipping ore and from the dumps. This yielded $419,962. The total revenue was therefore $1,886,966

and the profit $577,087. Dividends amounted to $360,000, and the balance on January 1, 1915, was $507,260, including that from the previous year.

Operations to date have resulted in the following: development, 272,779 ft.; ore treated, 2,040,722 tons; gross value, $38,274,933; and dividends, $9,817,080.

The report of the Stratton's Independence Mine, Victor, Colo., for the year ended June 30, 1914, shows a profit of $71,941 after deducting London office expenses. Development work was chiefly confined to proving up the mill veins at greater depths. Work in the productive area of the Independence did not disclose any new ore. The mill veins are to-day the sole source of shipping ore produced by the company. The lessees produced 18,736 tons, which was sorted to 7782 tons of ore having a gross value of $158,173 and a net value of $109,428 after payment of freight and treatment charges, of which the company got $34,991 for royalties and charge on profits. The company produced 19,785 tons of shipping ore which was sorted down to 3899 tons having a gross value of $68,740 and a net value of $46,806 after payment of freight and treatment charges. In addition to this ore the company treated for its own account 46,527 tons of ore in its mill, averaging $2.84 per ton. There was also 133,875 tons of dump ore treated. The average of all ore treated was 0.14396 oz. of gold per ton, of which 80 per cent. was recovered. The cost of milling, including moving dump ore, was as follows: Coarse crushing and sorting, 15.63 cts. per ton; fine crushing, concentrating and treating concentrates, 50.40 cts.; cyaniding and special chemicals, 46.72 cts.; miscellaneous, 14.25 cts.; mining dump ore, 11.1 cts.; total, $1.3810 per ton milled. It is expected that the dump ore will be exhausted this year. In speaking of the future it is stated that the company expects to be able to mine a grade of mill ore from the Independence that will pay the expense of mining and milling, and that some profit may come from occasional finds of shipping ore.

The report of Camp Bird, Ltd., for the year ended June 30, 1914, shows a profit on the Colorado property of $437,848. A dividend of $221,130 was paid. The ore reserves are estimated to contain 25,709 tons of ore that would yield a profit of $307,648. The mills treated 30,595 tons of ore yielding an average of $26.19 per ton; of this, 52.97 per cent. was recovered by amalgamation, 42.07 per cent. by concentration and 4.96 per cent. by cyanidation. Owing to the failure of some English financial houses in which the former chairman was interested, the company's affairs have been reorganized. H. C. Hoover is now chairman and R. J. Frecheville director of the technical committee.

The Vindicator Consolidated Gold Mining Co. performed a large

nount of development work during 1914, according to the annual re-ort. The shaft was sunk from the 1600-ft. level to 1943 ft. Con-derable money was spent on improvements, mainly in the form of a ew mill for concentration by washing and screening. The plant was escribed in *Metallurgical and Chemical Engineering*. The company hipped 26,343 tons of ore having a gross value of $712,400; lessees pro-luced 13,638 tons of a gross value of $323,667; total gross value of pro-luction, $1,036,067; freight and treatment charges, $233,787; gross proceeds, $802,280; total operating expense, plus payment to lessees, $501,420; profit from mining, $300,860. The concentrating mill cost $33,979, and a dividend of $270,000 was paid. Cash on hand January 1, 1915, was $208,270.

The total ore marketed by the Elkton Consolidated Mining & Mill-ing Co. in 1914 was 29,509 tons of a gross value at the mine of $542,280. The gross cash value to the company was $373,423. From the earnings a dividend of $200,000 was paid during the year. The surplus on December 31, 1914, was $299,763. The recession of water during the year amounted to 99.3 ft., but it is expected that with the further driv-ing of the Roosevelt tunnel the recession will be more rapid in 1915. The main shaft is now 1275 ft. deep and 365 ft. above the projected ele-vation of the projected drainage tunnel.

The annual report of the El Paso Consolidated Gold Mining Co., Cripple Creek, shows an excess of expense over earnings of $29,058. This is accounted for by the unusually heavy cost of development, 1629 ft. of development work having been done during the year. Other factors contributing to the deficiency were the lower value of ore mined, the destruction of the surface plant on November 4, and the expense of proving apex rights on the Ajax vein. During the year the Maid of Orleans and the Happy Jack claims, and an option on the Mollie Gibson, were purchased from the Henry Adney Co. for $38,500. Plans for a merger of Cripple Creek properties, in which the El Paso was to figure largely, were not consummated by President Burris, who had the matter in charge, and the company definitely retired from the proposition. Gross ore sales amounted to $307,025 and miscellaneous earnings brought the total up to $326,450. Expenses amounted to $355,508, leaving an excess of expenses over earnings of $29,058. A dividend of $49,000 was paid, and the amortization of the company's holdings in the Drainage and Tunnel Co. was completed.

Georgia.—The gold production of Georgia for 1914 was estimated at 552 fine oz., valued at $11,400. The silver output was only 100 fine oz. While the gold and silver mining industry of Georgia is of little consequence, there is a probability that it may develop to larger pro-

portions in the next few years. At the Seminole copper-gold mine there is a small smelter, and in the Dahlonega district there are several mills. While the latter are mostly relics of early operations, some of their sponsors are still engaged in mining. The concensus of opinion among those who should know is that the mines of Dahlonega can furnish a large tonnage of low-grade quartz ore if operated under competent management.

Idaho.—There was a decrease in gold production in this state in 1914, the output being estimated by Robert N. Bell, State Inspector of Mines, at 62,238 fine oz. The estimate of the U. S. Geological Survey and the Bureau of the Mint is 51,568 fine oz. For 1913 Mr. Bell's estimate was 67,792 fine oz. and that of the Survey 60,193 fine oz. The production of silver increased 30 per cent., being estimated at 12,689,500 fine oz. as against 9,889,193 fine oz. in 1913.

The decrease in gold output is attributed to the heavy falling off in yield at the De Lamar mine, in Owyhee County, and to the unproductiveness of the Lost Packer, in Custer County. The increase in silver production placed Idaho second in the list of silver-producing states, Nevada being the first. Nearly all the silver output came from lead ore and concentrate produced in the Cœur d'Alene district of Shoshone County. The mines contributing the largest increases were the Bunker Hill, Stewart, Caledonia, Sierra Nevada, Greenhill, Hercules, and Tamarack & Custer. The installation of flotation processes at most of the leading concentrating mills probably had a good effect on silver production.

In his annual report as Inspector of Mines, Robert N. Bell makes a sharp attack on national conservation and its effect on gold production. In his opinion, the degree to which the government carries its conservation policies, with particular reference to restrictions in acquiring title to mineral land and in the use of timber for mining purposes, is inimical to the development of the mineral resources. A specific instance is cited in which the De Lamar Co., one of the oldest and most important gold producers in the state, has been discouraged almost to the point of suspending operations on account of claims pressed by the government for mining timber used in years gone by.

The profits of Idaho mining companies, particularly those of the Cœur d'Alene district where so much of the silver is produced, were greatly reduced. This is to be ascribed mainly to the demoralised condition of the metal markets in the latter half of the year. Several operators were forced to suspend because their main production was lead, the market for which was poor.

Two dredging enterprises in Lemhi County were in successful opera-

ion during the year, one on Kirtley Creek and one on Bohanan Creek. The Boston-Idaho boat at Idaho City, in Boise County, also operated continuously. A notable production of gold was made from Gilmore and Allie mines in Lemhi County.

Montana.—In contrast to conditions in the adjoining state of Idaho, there was a decrease in silver production and an increase in gold output in Montana in 1914. The marked decrease in silver production is due to the curtailment of zinc and copper production, as Montana silver comes mainly from Butte copper and zinc mines.

The gold production for 1914 is estimated by the U. S. Geological Survey and the Bureau of the Mint at 190,361 fine oz., valued at $3,935,100, as against 160,647 oz., valued at $3,320,900, in 1913. The production for 1914 was greater than for 7 years past.

The production of silver decreased from 13,819,201 oz. in 1913 to 10,746,000 oz. in 1914.

The gold placers in Alder Gulch, Madison County, had an unusually good year. According to Theodore Simons, in the *Engineering and Mining Journal*, the Conrey Placer Mining Co. operated four dredges in Alder Gulch, handling 6,300,000 cu. yd. of gravel, and producing the bulk of the placer gold of the state. Silver Bow County was next to Madison, the gold coming chiefly from the copper ores of Butte.

Prominent among mines producing gold from dry or siliceous ores was the North Moccasin of the Barnes-King Development Co., at Kendall, Fergus County, whose output averaged $40,000 a month. Other more or less steady producers were the Keating Gold Mining Co., of Radersburg, Broadwater County, shipping 50 tons of $20 ore per day, the Southern Cross, Deer Lodge County, treating 500 tons a day of $8 ore by cyaniding, and a number of smaller properties in Madison, Blaine, Cascade, Granite, Fergus, Beaverhead, and Lewis and Clark Counties. In Lewis and Clark County a 60-ton cyanide mill was completed for the York Mining Co., and a 20-stamp mill for the Porphyry Dyke mine at Rimini.

The East Helena plant of the American Smelting & Refining Co. was in operation throughout the year. The normal capacity was 15,000 tons per month, of which 10,000 tons was silver-lead ore from the Cœur d'Alene district of Idaho.

Labor troubles developed in June between factions in the Western Federation of Miners, and street riots occurred in Butte. Miners Union Hall was dynamited. The local authorities were unable or unwilling to control the situation, and in September the town was placed under martial law for 2 months, during which time the state militia managed affairs. Order was finally restored and the law enforced against

the rioters, some of whom were sent to the penitentiary. Unionism has practically ceased to exist at Butte and open-shop conditions prevail to the apparent satisfaction of all.

Nevada.—The gold production of this state in 1914 represented about 40 per cent. of the total value of metal products. There was a falling off in gold output, the estimate being 532,309 fine oz., valued at $11,003,800, as compared with the 1913 output of 579,408 fine oz., valued at $11,977,400. The silver output also decreased from 16,090,083 fine oz. in 1913 to 14,814,300 fine oz. in 1914.

As in former years, the Goldfield district was the largest gold producer in the state. The Goldfield Consolidated Mines Co. produced 338,192 tons of ore, of which 332,750 tons of an average gross value of $12.57 was milled and 5442 tons of average gross value of $29.01 was shipped. Gross value of total tonnage, $4,340,786. Metallurgical losses, smelter discounts and other costs amounted to $414,438, leaving a value realized from the year's operations of $3,926,348. Expenses of mining, milling, transportation, construction, taxation and general were $2,091,124, leaving a net realization of $1,835,224. One dividend was paid, amounting to $1,067,744. A further dividend of half that sum was declared, payable in February, 1915. Total operating costs were $6.02 per ton, or 32 cts. per ton lower than in 1913, and net operating costs were $5.91 per ton, or 37 cts. lower. Development work amounted to 30,028 ft., at a cost of $7.32 per ft. Ore reserves comprise 141,500 tons of milling ore and 500 tons of shipping ore. A system of leasing sections of the mine was inaugurated and resulted in some discoveries profitable to the company. On June 25, 1914, the company acquired 87 per cent. of the issued shares of the Aurora Consolidated Mines Co., Aurora, Nevada, at a cost of $763,011. The property is equipped with a cyanide mill of 500 tons daily capacity. The early operation of the mill was delayed on account of difficulties encountered in the system of handling ore and the installation of two untried types of mill equipment. About $200,000 was expended in making necessary alterations in the mine and the mill. In spite of the poor start, the outlook is favorable for long and profitable operation.

The Jumbo Extension operated throughout the year and made some important discoveries. The Florence Goldfield made a total profit of about $85,000.

The Tonopah district produced approximately the same quantity of gold and silver in 1914 as in the previous year, according to Frederick Bradshaw. Twelve mines produced 129,886 oz. gold and 11,776,537 oz. silver from 547,979 tons of ore, while in 1913 the production from 11 mines was 120,189 oz. gold and 11,973,540 oz. silver from 551,710

of ore. The value of the product in 1914 was about $9,015,000 n 1913, $9,725,000. The gold-silver ratio in 1914 was higher than vious years, being 1:90.5 as against 1:99.6 in 1913. The reduced of silver was responsible for the decrease in total value of pro- on in 1914.

PRODUCTION OF TONOPAH MINES IN 1914

	Tons.	Oz. Gold.	Oz. Silver.	Estimated Gross Value.	Dividends.
h Belmont Dev. Co.....	179,706	43,864	4,182,537	$3,189,318.04	$1,462,500
h Mining Co. of Nev.....	144,323	37,275	3,206,275	2,446,000.00	1,000,000
h Extension Mg. Co.....	62,489	14,670	1,389,000	1,058,000.00	283,030
ler Tonopah Mg. Co.....	38,466	12,117	1,053,189	821,121.40	.....
nd Cons. Mining Co.....	55,850	11,190	1,072,882	793,242.72	268,273
a Tonopah Mines Co.....	44,267	6,230	456,707	383,963.44	.....
h North Star T. & D. Co....	5,232	1,462	145,314	110,650.00	.....
h Merger Mining Co.....	4,760	1,417	122,412	98,552.25	.....
Tonopah Mining Co.....	3,983	804	80,555	58,018.48	.....
mara Mining Co.....	8,021	631	45,471	38,697.62	.....
h Midway Mining Co.....	832	202	20,033	15,626.41	.....
Extension Co.....	50	24	2,162	1,551.49	.....
	547,979	129,886	11,776,537	$9,014,741.85	$3,013,803

he Jim Butler Tonopah Mining Co. had the most prosperous year history. The annual report for the year ended September 30, gives the following data:

he Belmont plant at Millers treated for the company 34,722 tons worth $744,799, yielding $247,800 net profit. In 1913 the results 19,181 tons, $383,957, and $104,682 respectively. The low price ver affected the revenue considerably. The treasurer's state- shows cash and loans on collateral valued at $235,781. There er stored worth $85,297. Work in the Wandering Boy area pro- l 20,533 tons of ore, and development totaled 7761 ft. The Desert n mine produced 14,189 tons of ore, and development amounted 12 ft. Ore reserves in the property consist of 34,642 tons of positive, 3 tons of possible, and 1832 tons of probable ore, a total of 50,197

he Tonopah Belmont Development Co. operated its 500-ton mill l capacity. Development disclosed high-grade ore in the Favorite The company's mill at Millers, Nev., was remodeled.

he Tonopah Mining Co. of Nevada developed new ground and new ore. The company's 500-ton cyanide mill at Millers was leled to an all-sliming plant, using continuous decantation with ved results. The Tonopah Extension Mining Co. increased its serves, so that they are greater than ever before. Ten stamps were to its 30-stamp mill, and two tube mills and eight concentrating were installed. A new Nordberg hoist and compressor were l at the new shaft.

The West End Consolidated opened new ore in the Ohio claim. The Montana Tonopah Mines Co. discontinued milling in September on account of the low price of silver, and prosecuted development work. The MacNamara Mining Co. temporarily suspended operations in August. Other companies operating during the year were the Tonopah Victor, Rescue Eula, Monarch Pittsburgh, Umatilla Tonopah, Buckeye, Belmont, Cash Boy, Gypsy Queen, and Tonopah East End. The area of known ore deposition in the district was extended easterly and westerly for a considerable distance.

Considerable activity was evident in the Rochester district. This region has long been known to be mineralized and has been the scene of some operations for many years, but not until 1912 did it attract much attention. The total shipments to September, 1914, exceeded $1,200,000. The lode deposits are replacement veins, mostly in rhyolite, and resemble those of the Mother Lode in California. The placers also resemble those in the Sierra Nevada of California. The Silver Belt railroad has been constructed into the district. The Rochester Mines Co. began the construction of a 100-ton cyanide mill on the continuous decantation system. The Seven Troughs Coalition, 30 miles west of Lovelock, produced over $250,000. The Rochester Weaver produced about $25,000 through the work of leasers. The Star Peak mine was developed with satisfactory results.

At Manhattan the War Eagle mill operated steadily. The Associated mill was overhauled and again placed in commission. The Manhattan Milling and Ore Co. produced about 100 tons of ore per day. A new 200-ton mill on the Big Pine claim is expected to add greatly to the output of the district.

The Comstock Lode was not so prosperous during 1914 as could have been desired. The event of most importance was the beginning of pumping operations in the Gold Hill mines by the Sturges interests. By April the old 1600-ft. level was recovered and prospecting was under way. A promising ore-body was subsequently developed on the 1500- and 1600-ft. levels of the Belcher, mill samples of which ran from $5 to $10 per ton. This is the first time since 1886 that any work has been done below the 1400-ft. level. Little work was done in the Virginia City mines during the first half of the year, owing to differences of opinion regarding the management of the pumping association. Scarcely had the differences been settled and operations begun when the European war broke out and effectually prevented further work.

The Boss mine in the Yellow Pine mining district, 10 miles west of Goodsprings, Clark County, attracted considerable attention on account of the discovery of gold ore containing platinum, palladium

nd iridium. A sample assayed at the Mackay School of Mines gave he following results in ounces per ton: gold, 38.92; silver, 10.96; platium, 12.28; palladium, 60.4. A carload of 56,167 lb. shipped to the merican Smelting & Refining Co. assayed: gold, 8.75; silver, 9.0; latinum, 1.1; palladium, 5.47. A 340-lb. sample gave the following esults in ounces per ton: gold, 111.00; platinum, 99.08; palladium, 6.0; iridium, trace. According to S. W. Mudd, the ore-body of chief nterest may be called a pipe, which outcrops at the surface. Part of he ore-body is quartz, surrounded by a shell of hematite 6 or 7 ft. in hickness. The hematite shell in turn is enclosed by malachite about in. thick. The country rock in the immediate vicinity is limestone, vhich adds interest to the occurrence.

The Nevada Hills Mining Co., with property 40 miles from the ailroad in Churchill County, made a net profit of $67,036 in 1914. Total costs were only $5.66 per ton. No dividend was paid. Mine levelopment amounted to 5679 ft., at a cost of $8.15 per ft. for driving nd cross-cutting, $6.30 for rising, $15.27 for winzing, and $62.48 for haft sinking, the total expenditure on this account being $46,782. The Weber shaft is down 935 ft., and the 900-ft. level opened. West of the "Big" fault the Nevada Hills vein system between the surface and 200 t. yielded a fair tonnage, and the east side, at 500 ft., produced a conderable amount of low-grade ore. Nothing of value was found at 00 ft. Regarding the Wingfield vein, it seems that it has "bottomed" n the hanging wall of the "blout" vein at 770 ft. Little hope is held that t will be found at depth. No commercial ore occurs in the Eagle vein elow 50 ft. The 503 vein is erratic in width and value, in places being ow grade, and others 12 in. wide worth $100 per ton, at 900 ft., which s encouraging. Ore reserves are about 40,000 tons, equal to a mill upply for 7 months. The cost of mining was $2.69 per ton of ore roduced, or $1.94 per ton of ore and waste.

The mill worked at 97 per cent. of the possible time and treated 4,348 tons, equal to 176 tons per day, with 88.8 per cent. recovery. This ore was worth $505,799, or $7.86 per ton. Silver extracted was pproximately 600,000 oz. Treatment cost $2.242, marketing concentrate and bullion 43.6 cts., and general charges 47 cts. per ton. Operating costs totaled $2.18 per ton below those of 1913. Quick assets are valued at $256,546, with no liabilities.

The report of the Nevada Wonder Mining Co., Wonder, Nev., for the year ended Sept. 30, 1914, shows a total production of 48,570 tons of ore having an average value of $15.52 per ton, of which 93.2 per cent. was recovered by the mill. Total receipts were $664,862 and operating expenditures, etc., $441,820, leaving a profit balance of $223,042. Divi-

dend payments amounted to $281,636, making a decrease of $58,594 in cash on hand as reported Sept. 30, 1913. The operating statements of the mining and milling company give the following costs:

	1912–13.	1913–14.
Mining cost per ton of ore	$3.37	$4.70
Shaft sinking per ton of ore	0.31	0.55
Enlarging shaft per ton of ore	0.18	0.04
Milling per ton of ore	3.25	3.37
Marketing products per ton of ore	0.24	0.28
Total cost per ton of ore	$7.35	$8.94
Average value per ton of ore	$14.63	$15.52
Loss in tailings per ton of ore	0.93	1.06
Recovery per ton of ore	$13.70	$14.46
Less total cost per ton of ore	7.35	8.94
Profit per ton of ore mined and milled	$6.35	$5.52

Development work amounted to 11,276 ft., making the total to date 29,916 ft. The cost of drifting, cross-cutting and raising averaged $6.44 per ft., and shaft sinking $30.80 per ft. for the Hidden Treasure shaft to $38.53 per ft. for the Nevada Wonder shaft. The stamp duty was 13.31 tons per stamp per 24 hr.

New Mexico.—There was an increased production of both gold and silver in 1914. Gold production was estimated at 58,418 fine oz., valued at $1,207,600, and silver at 1,682,100 fine oz. The figures for 1913 were 43,149 fine oz. gold, valued at $892,000, and 1,666,900 fine oz. silver. According to Charles W. Henderson of the U. S. Geological Survey, the Mogollon district, which in 1913 yielded $619,886 in gold and 1,306,766 oz. of silver, showed a small increase for 1914. Considerable metallic gold and silver were marketed from Pinos Altos, in addition to ores shipped. The output of the gold- and silver-bearing siliceous and copper ores of the Lordsburg district increased. The Whiteoaks district, Lincoln County, continued to produce gold bullion. The Elizabethtown district, Colfax County, remained the principal placer-producing district. The Oro Grande district, in Otero County, and the San Pedro district, Santa Fe County, contributed gold and silver in copper ores. The new 100-ton cyanide mill in the reopened Bland district, Sandoval County, continued to produce silver-gold bullion after September, and gold-silver bullion was produced at the cyanidation plants in the revived Red River district, Taos County.

Oregon.—The gold production for 1914 is estimated at 77,134 fine oz., valued at $1,594,500, and the silver output at 126,700 fine oz. In 1913 the gold production was 71,495 fine oz. and the silver production

72,200 fine oz. By far the largest production of gold, from both deep nd placer mines, continues to come from Baker County, which yields nnually about 84 per cent. of the total. Of the 175 producing mines n the state, 125 are placers.

According to the State Labor Commissioner, mining revived in the tate in 1914. The number of men employed was 578 and the total vage paid was $581,650. The Oregon Bureau of Mines and Geology, t Corvallis, was active in giving publicity to the state's mineral re- ources, and published a number of reports.

The Rainbow mine, in Baker County, was the most productive deep old mine in 1914, as in the preceding year. Other large producers in he same county were the Columbia, Cornucopia, Union, Last Chance, Ben Harrison, and Baker.

The most important placer producers were the Powder River Dredge o., Cracker Creek district, Baker County; Snyder Consolidated Gold Mining Co., operating a drift mine in the Granite district, Baker County; he Boulder Creek hydraulic and drift mine in the Cornucopia district; nd the Tom East hydraulic mine in the Grave Creek district. The ield from dredging operations was greatly in excess of that from all ther forms of placer mining combined.

South Dakota.—The gold production increased slightly in 1914, mounting to 355,621 fine oz. according to the estimate of the Bureau f the Mint and the U. S. Geological Survey. In 1913 the production as 348,988 fine oz. The silver production in 1914 was small, amount- ng to 180,500 fine oz., compared with 172,702 fine oz. in 1913. The tate mine inspector calculated the yield of placer gold at only $1800 for he year ended October 31, 1914. From 1876 to 1914, inclusive, South akota has produced $185,224,000 in gold and 5,830,000 oz. of silver.

The Homestake Mining Co. produced during 1914 the greatest ton- age of ore in its history. The mills treated 1,587,774 tons of ore yield- ng bullion valued at $6,160,161, or an average of $3.88 per ton. In 913 the tonnage milled was 1,540,961 and the bullion yield $1,186,652, n average of $4.01 per ton. Dividends in 1914 were the greatest in he mine's history, totaling $2,210,208 as against $2,146,225 in 1913.

The principal betterments consist of a completely equipped central oiler plant of six 600-hp. boilers; an electric generating station having maximum capacity of 4000 kv.-a., consisting of two units of steam urbines, condensing, direct connected to generators; a compound con- ensing steam hoist, designed to handle two 6-ton skips from a maxi- um depth of 4000 ft., skips dumping direct into two No. 8 Gates rushers; and a compound condensing air compressor with a capacity of 000 cu. ft. free air.

The B. & M. shaft was sunk from the 1550-ft. level to the 1700-ft. level and the Golden Star shaft from the 1250-ft. level to the 1400-ft. level, while 17,809 ft. of drifting was done during the year.

The annual report does not give unit costs, but the different items are about as follows:

	Total.	Per Ton.
Mining	$2,792,330	$1.759
Stamp milling	597,327	0.376
Regrinding	24,289	0.015
Cyaniding	294,548	0.185
General	501,233	0.315
	$4,209,727	$2.650

The Golden Reward company continued to operate its cyanide mill for siliceous ores and experimented further with the roasting-cyaniding of the sulphide or "blue" ore. The new Mogul mill at Terry was placed in operation early in 1914 and continued through the year. The mill uses the all-sliming process with continuous decantation without filtration, being the only one thus operating in the Black Hills. The Reliance uses continuous decantation with filtration. The Trojan mine and mill were operated at increased capacity. The Bismarck company ceased operations in its 200-ton cyanide plant in September.

The annual report of the Wasp No. 2 for 1914 shows the treatment of 176,140 tons of ore having an average value of $2.015 in gold and $0.287 in silver. Total recovery was $1.533, representing 73.31 per cent. of the gold and 34.77 per cent. of the silver. Costs were $1.287 per ton. Total profit for the year, including miscellaneous revenue, was $45,465, of which $30,000 was paid in dividends. Mining cost $0.661 per ton, using steam shovels to strip as much as 20 ft. overburden to get 20 ft. of ore. Milling cost $0.591 per ton. General expense was $0.035 per ton.

The U. S. Commission on Industrial Relations investigated conditions in South Dakota in August, 1914, examining many witnesses. A high tribute was paid to the management of the Homestake Mining Co.

Texas.—Estimates by the U. S. Geological Survey and the Bureau of the Mint place the 1914 gold production at 498 fine oz., valued at $10,300, compared with the 1913 production of 11 fine oz., valued at $200. The silver output is estimated at 601,000 fine oz. in 1914, compared with 429,800 fine oz. in 1913. The greater part of the silver production came from the Presidio silver mine and cyanide mill, Shafter district, Presidio County.

Utah.—The gold output of 1914 decreased about 7 per cent. as mpared with that of 1913, while the silver production decreased about) per cent. The estimated gold production was 153,842 fine oz., valued $3,180,200. The silver output was 11,397,500 fine oz. The value silver production decreased about $1,500,000, due to lower market ices as well as reduced production of lead ores from which silver is erived.

According to the *Deseret Evening News* of Salt Lake City, dividends aid by Utah mining companies totaled $6,996,118 in 1914, as against ',678,516 in 1913. The total dividends paid by Utah companies uring 50 years amount to $118,818,208.

The smelters near Salt Lake City produced, in 1914, 160,863 fine . gold and 12,821,378 fine oz. silver. The 1913 production of the me plants was 172,711 fine oz. gold and 13,084, 835 fine oz. silver. here were 198 producing mines in the state in 1914, yielding 8,618,832 ns of ore, as against 10,202,566 tons in 1913. The decreases noted ere due largely to curtailment of operations after the outbreak of the uropean war in August. Prior to that time the production had been rmal in practically all the districts.

The output of the Park City district was somewhat curtailed owing the suspension of shipments by the Daly West company, which lost mill and hoist by fire in 1913. A new mill and surface equipment ere completed during 1914. The Silver King Coalition built a large derground station on the Alliance tunnel level. The Daly-Judge perimented with flotation by the Callow process. The Silver King nsolidated opened a large new ore-body. The Mines Operating Co. eated stope filling from the Ontario mine by its chloridizing-roasting aching process, producing considerable silver. Holt-Dern roasters ere installed in the latter part of the year. The Park City Milling Co. so adopted a similar process at the old Grasselli zinc mill, treating ver ores. After a short period of operation the mill was closed for terations.

The Tintic district was the largest silver-producing portion of the ate. Here also a chloridizing-roasting and leaching process was veloped at the Knight-Christensen mill.

In the Bingham district the Utah Apex, Bingham-New Haven, Utah nsolidated, and the United States properties were the principal ippers of silver-lead ores.

The annual report of the Daly-Judge Mining Co. for 1914 shows total mine output of 54,701 tons of ore, of which 49,095 tons was concentrating grade and 5606 tons of shipping grade. This is an crease of 804 tons over 1913. The metal contents of the finished

products were 723.6 oz. gold, 519,979 oz. silver, in addition to lead, copper and zinc. Operations were suspended in August for about 40 days on account of the lack of a silver market. The annual dividend of $180,000 was paid as usual, in spite of the suspension. Development and dead work for the year, excluding all work done in ore, was 11,558 ft. The irregularity of ore occurrence precludes making an estimate of ore reserves, but it is stated that there is an unusual amount of milling ore in sight. The cost of extracting 54,701 tons of ore was at the rate of $3.067 per ton. Cost of concentrating 49,095 tons of ore, $0.763 per ton.

Washington.—There was a decrease in both gold and silver production in this state in 1914 as compared with 1913. The gold output is estimated at 29,383 fine oz., valued at $607,400, as against 31,806 fine oz. in 1913, valued at $657,500. The silver output decreased from 331,239 fine oz. in 1913 to 254,100 fine oz. in 1914. Nearly a third of the total silver had its origin in copper ores, and as the copper production was largely curtailed, the silver production suffered.

About 60 per cent. of the gold came from ore and concentrates shipped to smelters, and the balance came from mill bullion and placers. The Republic district was the principal gold producer, but the output was lower than in 1913. The Ben Hur was the largest producing mine, shipping about 25,000 tons to Canadian smelters. The San Poil was the only mill in operation, treating about 80 tons a day. In October the Western Union Mines Co. acquired the Surprise, Line Pine, Pearl, San Poil, Last Chance, and Quilp mines.

Wyoming.—This state is a minor producer of gold and silver. The 1914 output of gold is estimated at 106 fine oz., a marked decrease from the 1913 production of 847 fine oz. The silver production in 1914 was 100 fine oz., as against 1200 fine oz. in 1913. There was a small yield of mill and placer bullion from the Atlantic City district. Work was resumed at the property of the Rambler Copper and Platinum Co., Holmes, Wyo.; the mill was remodeled and put in operation on dump ore.

Gold and Silver Mining in Foreign Countries

The collection of accurate data and statistics from foreign countries is usually a difficult matter in normal times, but was especially difficult and unsatisfactory in 1914 on account of the disturbance of international relations by the European war. Hence it has been necessary to omit entirely some data which formerly were available, and in other cases to make estimates based on incomplete information. Whether the figures of production are correct or not is not so material as the tendencies they

ndicate, and in this latter regard there is no reason to doubt the infor-nation presented in the following pages.

Africa

The principal gold-producing regions of this continent, in the order f their importance, are the Transvaal, Rhodesia, West Africa, and he Congo. The aggregate gold production of all Africa in 1914 was pproximately 45 per cent. of that of the entire world. The output f the Transvaal declined; that of Rhodesia and West Africa increased; nd it is likely that these tendencies which were exhibited in 1914 indi-ate what may be expected in the coming years. The minor produc-ion of Egypt and Madagascar remains about the same.

Central Africa.—On account of the war few reports are available s to progress at the placers in the northeast part of the Belgian Congo—Kilo, Moto, Babeyru, and Kanwa. The production for 1914 is probably bout $900,000. Between 1904 and the end of 1914 the placer gold roduced in this colony is valued at about $4,052,500. The present ate of production indicates that the next 5 years will see as great production as was witnessed in the past decade. New discoveries re reported every year, but no lodes or veins have been found.

According to the *Mining Magazine*, Kilo is the most important of he placers, occurring in a diorite and granite country. The gold is resumably derived from pyritiferous quartz stringers in the diorite and long its contact with the granite, as the streams become barren upon eaving the diorite and pass into the granite. The gravel ranges in con-ent from 22d. or less to 150s. per cu. yd. The overburden and "pay-treak" vary much in thickness, reaching a maximum of 4¾ ft. and aver-ging about 1⅓ ft. The bottom consists of greenish clay, the altered iorite country rock, and the gold penetrates it for 4 and, in instances, ven 8 in. The gravel is excavated largely by pick and shovel, although n part by a small giant, and the gold is recovered in sluices. To date bout £520,000 has been produced, and over £1,000,000 worth of ravel is said to be blocked out. About 30 whites and 2000 blacks are mployed.

Moto is a much smaller placer. It was first operated in 1911 and as produced about £120,000, with a larger amount still to be ex-racted. Seven whites and 1300 blacks are employed. The country ock is reported to be granite, diorite, and hematite schists.

The Kanwa placer lies at the headwaters of the Tele River in a eavily wooded, ruggedly dissected plateau country. The country ock is a schist-gneiss complex, cut by granite dikes and masses. Be-

low quartz stringers, which occur in the complex, the gravel is enriched. At Babeyru a placer is just beginning production.

Gold is widely distributed in the Katanga, and detrital and placer gold deposits are derived from the breakdown of five of the copper deposits, the copper ore as noted above being slightly auriferous. The Ruwe lode in the Katanga copper belt is interesting. Structurally this resembles the Katanga tabular bodies, and indeed some copper is present. The mineralized portion of the sandstone is reported to be 1200 ft. long and to vary in width from 3 to 20 ft., averaging 8 ft. The assay values are uneven and are said to average 70s. per ton in gold, platinum, palladium, and some silver. Downhill from the lode is a detrital gold deposit from which, 8 years ago, about £40,000 was won.

The colonial authorities have shown a disposition to reserve the right to purchase all gold produced in the Congo. In the decree granting the Kasai company the right to prospect certain parts of the Aruwimi watershed, and in the new draft of the mining laws of the Katanga, is a clause giving preference to the colony and the Belgian government as buyers of gold.

Rhodesia.—The gold output of this colony in 1914 was 854,480 oz., valued at £3,580,209, an increase over 1913 of 164,526 oz., or £676,941 in value. The silver production in 1914 was 150,832 oz. The gold production has shown a steady increase in value each year. There were 202 mines producing in 1914. Dividends were paid in the sum of £502,303 by 12 companies. The Rhodesian Chamber of Mines reports about 35,000 native laborers employed in the mines of Southern Rhodesia.

The following is a brief summary of the gold output for 1914 of the different districts, the feature of which is the fact that the Gwelo district alone produced during 1914 over a million sterling—or practically the same amount as the gross production by the country only 10 years ago:

	1913.	1914.
Bulawayo	£780,928	£845,565
Gwelo	901,578	1,005,230
Hartley	638,794	772,095
Lomagundi	200,876	173,858
Mazoe	134,603	172,827
Salisbury	32,663	362,245
Umtali	198,989	206,148
Victoria	14,837	42,841

The Acting Director of Mines for Manicaland reports the following details of gold and silver production for 1914:

	Gold, Oz.	Silver, Oz.
ef batteries	4,562	1,882
anide	184	172
acentrates	142	501
uvial	10,375	826
Grand total	15,263	3,381

During the year 1913 Rhodesia produced over 3 per cent. of the orld's yield of the precious metal, passing in the list of the great pro-ucing countries such old-established industries as those of Canada, ıdia, West Africa, Victoria, and New Zealand, and standing sixth in tio of production after the Transvaal, United States, Australia (as one ate), Russia, and Mexico. In view of the diminished output of other lds, the contribution of Rhodesia is likely to rank higher for 1914 an ever.

The returns of the individual mines show that the Globe & Phoenix the largest producer, its output being valued at £516,116. Next in der come the Lonely with £219,134; Eldorado, £185,234; Giant, 139,476; Rezende, £131,979; Wanderer, £73,862. All except the last owed marked increases as compared with 1913.

The Giant Mines of Rhodesia, Ltd., treated during the year ended ne 10, 1914, 123,320 tons of ore yielding £99,577. The net profit as £34,189. Costs totaled $2.45 per ton.

The Lonely Reef showed a decrease in monthly production during e latter part of the year, due to the lower grade of ore and shortage of ater. The cost per ton rose from 28s. in August to 36s. in October, due rgely to the diminished tonnage, from 6090 to 4030.

The Cam and Motor had metallurgical difficulties during the year, ıd although extraction increased from 57 to 69 per cent., it was ill far short of anticipations. The Golden Kopje also had similar ouble.

Directors of the Globe & Phoenix visited the property in August, 14, and in October they reported satisfactory conditions existing. September the ore reserves were officially estimated at 188,000 ns of 29.1 dwt. ore. A plant is now successfully treating the sand mp which is estimated to contain £400,000, an average of 6 dwt. per n. Capital expenditure paid out of earnings has exceeded four times e original capital of £200,000, and dividends have exceeded capital eight times.

Transvaal.—Though the gold output of this British colony in 1914 l short of that for 1913, being only 8,378,139 fine oz. in 1914 as com-ıred with 8,794,824 fine oz. in the previous year, it probably main-

tained its relative importance among the world's gold-producing countries and supplied about 40 per cent. of the total. In the final figures the percentage will not be lower than 38. Following is a summary:

GRAND TOTALS AND AVERAGES, TRANSVAAL GOLD PRODUCTION. THE RAND AND OUTSIDE DISTRICTS[1]
(1 fine oz. = £4.24773)

	1913.	1914.
Tons milled	26,267,840	26,369,946
Stamps working	9,912	9,757
Tube mills working	287	294
Yield, total value	£37,358,040	£35,588,075
Yield, total fine ounces	8,794,824	8,378,139
Yield, value per ton	28s. 0d.	26s. 8d.
Yield, dwt. per ton	6.60	6.28
Working cost, total	£23,628,007	£22,654,845
Working cost, per ton milled	18s. 1d.	17s. 3d.
Working profit, total	£12,660,796	£11,979,339
Working profit, per ton milled	9s. 8d.	9s. 1d.
Dividends declared	£8,596,532	£8,404,060

The Kerksdorp district produced 154,778 tons of ore yielding 37,775 oz. gold, valued at £160,524.

At the beginning of 1914 the outlook for mining in the Transvaal was brighter than for many years past, and in some respects the anticipations were realized. A larger tonnage was milled and the cost per ton was lowered. On the other hand, the yield per ton and the working profit per ton fell off. Dividends also were less.

The Rand, as a whole, has passed its zenith; the mines in the west are giving poorer results, while many of those in the central Rand are stationary or beginning to decline. On the other hand, prospects are bright for the mines in the far east Rand.

The requirement of large capital for Rand mining is illustrated by the experience of the Daggafontein, which cut its lode at a depth of 3580 ft. At that time there had been expended £248,550 on the shaft and £49,396 in boring, and there was still required the sum of £750,000 to bring the mine to the productive stage.

Statistics on Transvaal labor showed that about 22,000 whites and 182,000 natives were employed. The death rate of the latter has fallen from 35.72 per thousand in 1910 to 19.32 for the 12 months ended in September, 1914.

The health of Transvaal miners received considerable attention during the year. The South African Institute of Medical Research completed its establishment at a cost of £42,000, and invited two experts from the Rockefeller Institute to study pneumonia on the Rand. The Transvaal Chamber of Mines also made an investigation of the

[1] *Transvaal Chamber of Mines Monthly Analysis.*

ame subject through Sir Almroth Wright and General Gorgas, at an xpense to the mining industry of about £22,544. The Union Parliament mended the Miners' Phthisis Act of 1912, providing additional com-ensation to miners suffering from phthisis.

West Africa.—The gold output of this country in 1914 showed a narked increase over that of 1913, the respective figures being 419,510 z., valued at £1,727,044, and 397,679 oz., valued at £1,634,700. The record production was made in October, when the output was 8,879 oz.

The Ashanti Goldfields Corporation, Ltd., is the most important ompany in West Africa. The report for the year ended June 30, 1914, hows that 117,867 tons of ore was treated for a yield of 101,579 oz. old, and that 16,625 tons of old tailing yielded 2260 oz. gold. Of the re treated, 52,539 tons came from the Obuasi shoot, 15,268 tons from he main workings of the Ashanti mine, 26,695 tons from the Ayeinm ine, and 19,706 tons from other properties. The income from the ale of gold was £447,947. The working cost was £213,257, cost of evelopment £45,558, government royalty £22,164, and allowance for epreciation £21,237, leaving a profit of £145,731. The dividends bsorbed £147,326, being at the rate of 68¾ per cent. As compared ith the previous year, the ore treated was 30,500 tons less, the total ield 6380 oz. less, and the dividends £40,500 less. The developments uring the year have added to the reserve, for which the figures are: shanti main workings, 34,100 tons averaging 21.08 dwt.; Obuasi shoot, 13,400 tons averaging 27.3 dwt.; Ayeinm, 120,000 tons averaging 10 dwt.; ustice's, 65,000 tons averaging 11 dwt.; total, 432,500 tons averaging 9.5 dwt. The increase in tonnage is chiefly in the Obuasi shoot, though he content of the reserve in that shoot is 4 dwt. less than a year ago. The reserve will, it is estimated, provide profits at the rate of £150,000 er year for 4 years.

The Central treatment plant, using roasting and direct cyanidation, ealt with 97,293 tons of ore yielding $20 per ton, with 93.2 per cent. xtraction. The Côte d'Or filter-press plant treated 16,915 tons yield-ng $9.40 per ton, with 80.1 per cent. recovery. The Côte d'Or plant lso treated 15,501 tons of tailing giving $2.70 per ton.

The prospects of the Abosso have been brightened by the discovery f a new lode parallel with, and similar in general character to, the main ode. A stretch of 371 ft. of ore averaging 37s. per ton for 80 in. has een found in this new lode and vigorous exploratory work is under way. t the Taquah the reserve has decreased by only 7000 tons, although 3,746 tons of ore was crushed during the year.

The mining regulations are reported unsatisfactory, resulting in

a high death rate from accidents. In 1911 the accident death rate per thousand was 4.84; in 1912, 5.46; in 1913, 9.01.

Asia

The principal gold-producing countries grouped under this head are India, Korea, and the Philippine Islands. Japan has some gold and silver mines, but the great copper mines, Ashio, Besshi and others, add to the gold and silver output. Some lode and placer mines on the island of Formosa also produce a substantial quantity of the precious metals. Gold is produced in a primitive manner in China from widely distributed sources, but there is no established industry such as is found in other countries.

China (by T. T. Read).—New discoveries of placer deposits have recently been reported from Huo-shui-ying, in Hei-lung-chiang, and it is stated that the new district is expected to afford employment for 3000 workmen for 20 years. The operations of the Mongolyr company, in Mongolia, were described in the *Mining and Scientific Press* of Sept. 12, 1914, p. 410, and further information on gold mining in Mongolia is given in the same journal for Oct. 31, p. 687, and Dec. 12, p. 922. Gold is produced in many parts of China, but Manchuria, Mongolia, Ssuchuan, and Yunnan are the only districts of much importance.

The Anglo-Chinese Mining Co., with joint British and Chinese capital, has been formed to work a recently discovered silver mine at Lung-Chiao-Shan, Tayeh. The mine is said to be rich. The Hankow Tao Chen Metallurgical Co., Ltd., with Chinese capital, has been formed to work mines under the supervision of the government, and is now engaged in developing a silver mine in Hupeh.

India.—The gold output of this country in 1914 was 596,419 oz., as compared with 589,109 oz. in 1913. The principal producing district is the Kolar gold fields, where English companies have operated for many years with conspicuous success. Profitable ore has been found at great depths, the circular shaft on the Champion Reef being complete to a depth of 3861 ft. vertical. The Mysore government has taken steps to prevent a shortage of power by building a dam at the Cauvery Falls.

The Champion Reef enjoys continued prosperity, although the grade of ore has fallen from 1½ oz. in 1900 to 1 oz. in 1905 and 9 dwt. per ton in 1914. The report for the year ended September 30, 1914, shows improvement as compared with conditions in 1909, at which time they were least favorable. The quantity of ore milled was 216,943 tons; tailings cyanided, 334,494 tons; total yield, 124,497 oz. gold, valued at £527,500.

e working cost was £302,011, or 27s. 10d. per ton, and £29,389 was id as royalty. Dividends were paid at the rate of 53⅛ per cent., as npared with 160 per cent. in 1905 and 20 per cent. in 1909. Develop- nt amounted to 17,334 ft., and the ore reserve is 477,000 tons, being an rease of 73,000 tons over that of the previous year.

The Mysore Gold Mining Co. paid during the first 8 months of 14 dividends equivalent to 7s. per share.

The North Anantapur Gold Mines, Ltd., reported as follows for the ar ended June 30, 1914: 25,450 tons of quartz was milled, yielding 10,- 7 oz. gold; 16,410 tons of tailings was cyanided, yielding 1007 oz.; total, 994 oz., valued at £46,888. The value of the 1913 yield was £35,867. e receipts for 1914, allowing for royalty to the Indian government, were 6,795; costs, £34,863; profit, £11,932. Dividends amounted to 20 per nt. on preference shares and 6d. per share on preference and ordinary ares. Ore reserves were increased by 8000 tons, being 52,000 tons on ne 30, 1914.

Japan.—The value of gold production in 1914 was $4,476,500. The ver output amounted to 4,647,767 oz. Among the gold mines produc- g more than $50,000 were the following: Hidachi, $1,803,873; Sado, 67,167; Yamagano, $281,113; Kushikino, $238,605; Kosaka, $225,452; umaishi, $146,518; Tomiki, $105,902; Serigano, $83,803; Abeshiro, 1,087; Okayabu, $70,178; Nishinomiya, $67,680; Matsuoke, $66,145; nori, $61,220; Okuchi, $56,387; Miyagi, $55,213; Ushio, $51,368; robetsu, $50,355; Ikuno, $50,290. Thirty-seven other mines produc- g less than $50,000 each had a total output valued at $547,795.

The silver mines producing more than 60,000 oz. were: Kosaka, 6,885 oz.; Hidachi, 802,700; Tsnbaki (closed in September), 460,668; hio, 320,035; Kamioka, 283,620; Ikuno, 221,968; Abeshiro, 232,914; do, 166,257; Kushikino, 126,084; Omodani, 119,838; Omori, 119,140; konai, 85,124; Kunitomi, 66,492; Yoshioka, 64,944; Ani, 60,969. ere were 45 other mines producing less than 60,000 oz. each, having aggregate output of 578,061 oz.

Korea.—The Oriental Consolidated Mining Co., Chosen, had a fitable year. The report for the year ended July 31, 1914, shows al receipts of $1,731,472; operating cost, 994,733; construction and elopment, $113,959; net receipts, $622,780. The mines produced ,162 tons of ore averaging $6.85 per ton. Of this, $3.44 was recovered amalgamation and $2.16 by cyaniding concentrates; net yield, 60 per ton. Total cost per ton was $3.68, of which the cost for ning was $1.98; for milling, 56 cts.; cyaniding concentrates, 32 cts. vidends amounted to $644,085. The following table gives the results cyaniding concentrates at the different plants:

	Tons Treated.	Assay Value per Ton.	Extraction.		Cost of Treatment per Ton.
			Per Ton.	Per Cent.	
Tarcol tube-mill plant	12,856	$30.83	$24.72	80.2	$4.58[1]
Tarcol cyanide plant	10,285	29.83	24.60	82.5	1.63
K.S.D. plant	4,552	25.04	14.80	59.1	1.87
K.S.D. dump retreatment	12,646	7.37	4.70	63.8	3.18
Candlestick plant	7,778	3.56	1.91	52.4	1.08

In the mill the items of milling cost were: supplies, 25.75 cts. per ton; assays, 0.896 ct.; shops, 2.716 cts.; electric power, 11.16 cts.; salaries and board, 8.239 cts.; pay-roll, 6.764 cts.; total, $5.525 per ton.

The items of mining cost were: supplies, 92.846 cts. per ton; assays, 0.516 ct.; shops, 2.881 cts.; salaries and board, 13.592 cts.; pay-roll, 79.397 cts.; electric light and power, 8.73 cts.; total, $1.97962 per ton.

Philippine Islands.—The Division of Mines of the Bureau of Science estimates the value of the 1914 gold production at 2,406,867 pesos, an increase of about 39 per cent. over that of 1913, when the value was 1,736,724 pesos. A little more than half the 1914 production came from lode mining and the balance from dredging. Silver is produced only as a by-product of gold mining, and had a value in 1914 of 16,000 pesos.

According to J. F. Boomer, Manila correspondent of the Department of Commerce, the mining industry in the islands is getting on a firm basis, and an increase in gold output may be confidently expected. New centers of operation are being opened and new plants constructed. So flourishing has the mining industry become that the collector of internal revenue proposed that the legislature place a tax of 5 per cent. on the output of gold from the mines. This was opposed by the mining interests as being excessive and premature and likely to injure the industry. As a compromise, a tax of 1.5 per cent. was recommended to the legislature and was expected to pass.

Dredging in the Philippines was active in 1914. The most successful company was the Gumaos, which averaged about 65,000 cu. yd. per month. The clean-ups during the first half of the year were about 18,000 pesos per month, but later the clean-ups increased to $30,000 and $35,000 per month. This company's dredge has operated almost uninterruptedly since its installation, about 23 months ago. It operates under rather severe conditions, on account of the clay and buried timbers contained in the gravel. While the company's dredge operated without interruption or breakdowns of any consequence, the corporate management developed friction which resulted in changes in the personnel of the

[1] Closed on account of high cost.

board. Philippine Dredges, an Australian company, operated its dredges more or less continuously during 1914. In October the yield for two dredges was 736 oz. of gold and for the third 39 oz., the last having been stopped for repairs to boiler. No. 4 dredge was started in October. The November clean-up was 701 oz.; two dredges were undergoing repairs. The Malaguit Dredging Co. operated in 1914, but was closed down for a period for repairs and changes to the boilers, screens and tables.

Prospecting with Empire drills in the Gumaos district gave the following results:

Twenty-three tests showed an average value of $0.19836 per cu. yd., covering a lot of ground containing 160,000 cu. yd.; 23 other tests showed an average value of $0.1671, covering ground containing 210,000 cu. yd.; 23 other tests showed an average value of $0.2694 per cu. yd., covering 194,000 cu. yd. Two other tests showed an average value of $2.92 and of $2.28. The last two tests mentioned were not taken into account in estimating the averages; had that been done, the average for the entire area covered by the 75 soundings would have been $0.495 per cu. yd. The valuable ground sounded covered 564,000 cu. yd., with an average value of $0.2111, or a total value of $218,093.

The ground outlined above is expected to keep one dredge working for about 8 months, making allowances for the most unfavorable conditions likely to be met in the operation of the dredge. The savings of the dredge on this ground should be $13,200 to $14,100 per month. The ground covered by the report is only a small portion of the holdings of the company, which is but one of many in the Gumaos region.

According to a writer in the *Philippine Bulletin*, the Paracale field is estimated to contain about 3000 acres of profitable dredging land, which will keep a good-sized fleet of dredges at work for several years. Prospecting parties have spread throughout the islands, and already several thousand acres have been proved by testing to warrant the installation of dredging plants thereon. Some of the largest operators in the world are invading the field and the future of gold dredging in the Philippines is promising.

The Colombo Mining Co. has been operating successfully, paying two 5 per cent. dividends and leaving a surplus of 400,000 pesos. Ore is being produced at the rate of 150 tons a day. The Syndicate at Masbate also did well. At the Benguet Consolidated the erection of a modern cyanide mill was started, consisting of stamps, tube mill and classifier, followed by the continuous decantation system for slime.

AUSTRALIA

Reports under this head cover the states of Australia and the Dominion of New Zealand. A large quantity of the gold and silver produced in these countries comes from base-metal mining and reduction. All of the states of the Australian Commonwealth had a decreased gold output in 1914 as compared with 1913, even Western Australia falling behind its previous record. Although New Zealand had a small increase, it was not enough to counterbalance the deficiency of the states, so that the total Australian production fell off.

PRODUCTION OF GOLD IN AUSTRALIA (a)
(In fine ounces)

State.	1907.	1908.	1909.	1910.	1911.	1912.	1913.	1914.
New South Wales	247,363	224,792	204,709	188,857	181,121	165,296	149,667	134,887
Northern Territory	5,160	5,633	5,682	5,109	(e) 5,000	(e) 5,000	(e) 4,000	(e) 4,000
Queensland	466,476	465,085	455,577	441,400	386,164	347,946	265,735	243,326
South Australia	4,834	2,898	7,111	6,603	3,537	6,592	7,292	6,600
Tasmania	65,355	57,085	44,777	37,048	31,101	37,973	33,440	27,230
Victoria	695,576	671,208	654,222	570,383	504,000	480,131	434,922	402,705
West Australia (b)	1,671,993	1,596,091	1,576,406	1,422,231	1,338,987	1,282,658	1,314,044	1,322,934
Commonwealth	3,156,757	3,022,792	2,948,484	2,671,631	2,449,910	2,325,595	2,209,700	2,053,402
New Zealand (c)	477,312	471,967	472,465	446,434	427,385	310,796	343,627	(e)361,272
Total Australia	3,634,069	3,494,759	3,420,949	3,118,065	2,877,295	2,636,391	2,553,327	2,414,674

(a) From official publications. (b) Production reported by the Mines Department; in previous volumes the statistics have represented exports. (c) Exports. (e) Estimated.

The high-water mark of Australia's gold production was in 1903, when the output was 3,837,064 oz. Since then the decline has been continuous. The value of the gold production of the Commonwealth has been about 66 per cent. of the value of the total mineral output. Silver has not been of much importance. New South Wales has been by long odds the greatest producer of silver, the total value of its silver output from the beginning being £46,377,574.

Gold received for coinage at the Australian Mints during 1914 was as follows: Sydney Branch, 458,824 fine oz., value, £1,948,960; Melbourne Branch, 479,977 fine oz., value, £2,038,813; Perth Branch, 1,451,683 oz., value, £5,019,840. The total purchases made by banks during 1914 amounted to 161,330 oz., as compared with 168,585 oz. in 1913.

New South Wales.—The failure of the Great Cobar in August accounts for part of the decline in gold production, because while the property was mainly a copper producer, there was considerable gold recovered from the 10-dwt. siliceous flux. The premier gold mine of the state is the Mount Boppy.

The yield from the dredges, which in the aggregate forms a considerable proportion of the total, was well maintained. The chief centers of dredging operations were Araluen, Adelong and Braidwood.

Adelong Gold Estates reported 419,250 cu. yd. of ground treated for a yield of 2658 oz. gold, of which No. 1 dredge contributed 704 oz. and No. 2, 1954 oz. The financial statement shows a profit of £3746. The average earning per cu. yd. of No. 2 dredge was 7.259d. and costs 3.239d.; for No. 1 the earning was 4.058d. and costs 4.848d. per cu. yd. No. 1 dredge was out of commission for some months for reconstruction.

The production of silver was seriously curtailed on account of the necessity of reducing the production of lead-zinc ores at Broken Hill. This district is the great center of silver production, the precious metal occurring with base metals. When the European war broke out the Australian zinc producers were prevented from shipping because contracts for smelting most of the product were held by German concerns. Attempts were made to interest British and American capital in the building of new smelters, but the legality of new ore contracts was questionable and the matter was dropped. The flotation process of concentration continues to play an important part in Broken Hill ore treatment. Preferential or selective methods of flotation were developed in a higher degree.

During the 6 months ended June 30, 1914, the Broken Hill South Silver Mining Co. treated 172,330 tons of ore containing about 15 per cent. lead, 13 per cent. zinc and 7 oz. silver per ton. Stope filling amounted to 41,836 cu. yd., placed in the mine at an average cost of 92 cts. per cu. yd., or 21.6 cts. per ton of ore produced. Average earnings of contractor's mining was $4.45, and of trammers $3.50, per shift. Working cost per ton of ore was $5.20, made up of mining, $3.13; filling, 22 cts.; development, 83 cts.; concentration, $1.02.

The total value of 1914 mineral exports from Broken Hill was £3,446,491, of which £2,630,401 represented silver-lead ores and concentrates. In 1913 the respective figures were £4,327,217 and £3,171,433.

Queensland.—The fall in gold production in this state was due chiefly to the exhaustion of the Charters Towers deposits. As in New South Wales, a great deal of the gold produced in this state comes from base-metal ores, in this case copper. The principal producer is the Mt. Morgan Gold Mining Co. During the half year ended November 29, 1914, the total revenue of this company was £502,382, of which £438,546 was spent in operating, development and depreciation. The surplus was £63,836, from which a £50,000 dividend was paid. During the half year 179,939 tons of ore was smelted and 31,274 tons concentrated. Production amounted to 4593 tons of fine copper and 58,309 oz. gold. The concentrating plant has shown its ability to treat ore successfully and economically, with recovery of 87.4 per cent. of the copper and 77.5 per

cent. of the gold. A sintering plant was put in successful operation, and basic-lined converters were installed.

The general manager, B. Magnus, reported as follows: "It is hoped that new work to be done at the mine to equip it for the maximum output will be finished during the present term. Development totaled 2484 ft., and ore reserves consist of 1,123,000 tons of high- and 1,849,000 tons of low-grade material. Ore mined down to 950 ft. consisted of 171,355 tons, against 131,133 tons in the previous half year. The Many Peaks pyrite mine supplied 32,112 tons. The new blast furnaces started in July and have reduced costs of treatment. Concentrate from the flotation plant gave some trouble on account of its fineness. The smelter treated 179,939 tons of mixed ores."

South Australia.—The year 1914 has been reported as the worst on record as far as mining in this state is concerned. The returns on gold mining can only be estimated, but they show a decrease as compared with 1913. A revival of gold mining has been predicted in the Tarcoola district when the East-West railway is constructed, but of course it is apparent that something more than a railroad will be necessary to make gold mining profitable. In fact the question as to whether South Australia has or has not any mineral resources may be a subject for Parliamentary inquiry through a commission. If natural resources of importance exist, why the dilapidated state of the mining industry; if none exist, why support a Department of Mines? Such is the attitude of a correspondent familiar with conditions.

Tasmania.—The gold output for 1914 is estimated at 27,230 oz. as compared with 33,440 oz. in 1913. The closing of the Tasmania mine at Beaconsfield, on account of water in the lower levels, accounts largely for the decrease. An attempt to work the mine on a leasing basis was unsuccessful. The Mount Lyell continued through the year as an important producer of gold and silver as by-products from copper smelting and refining. For the 6 months ended September 30, 1914, the production was as follows: the treatment of 163,513 tons of ore yielded 3391 tons of copper, 231,740 oz. silver and 4504 oz. gold. During the 20 years of its operation the Mount Lyell has been an interesting mining and metallurgical proposition, being one of the few instances in the world where conditions are most favorable for pyritic smelting. The *Transactions of the American Institute of Mining Engineers* contains data on the operation, contributed by General Manager Robert C. Sticht at a meeting in New York, Dec. 2, 1914.

Victoria.—Both lode and placer mining contribute to the gold output of this state, which amounted to 409,706 oz. in 1914 and 434,932 oz. in 1913.

Official returns from placer mining in 1913 show a production of 65,433 oz. gold from 16,796,585 cu. yd. The yield per cu. yd. was 1.9 grains gold. Operations were distributed as follows:

	Cu. Yd.	Oz. Gold.	Grains per Cu. Yd.
51 Bucket dredges	**14,946,933**	**52,212**	**1.6**
26 Pump sluicing plants	**1,191,817**	**8,957**	**3.6**
15 Jet elevators	**567,273**	**3,665**	**3.1**
5 Hydraulic sluicing plants	**90,562**	**599**	**3.2**
97 Plants	**16,796,585**	**65,433**	**1.9**

Bendigo is the most important lode mining district, and here deep mining has failed to pay and has had to be discontinued, work being concentrated in the upper levels. No extensive scheme of development has been carried on, either in Bendigo or the surrounding districts. Castle is regarded as a promising field for prospecting. Ballarat has been quiet, and work has come to a standstill. Until new developments are made, Victoria must rely for its gold production on the old mines.

In 1914 the Bendigo district produced 163,601 oz. gold, a slight reduction as compared with 1913. Dividends totaled £126,878, an increase of over £29,000 as compared with 1913. Calls aggregated £61,841, the smallest contribution by shareholders for 50 years. The number of dividend-paying mines increased from 18 in 1913 to 23 in 1914. Following are data on the principal producers.

Company.	Tons.	Ounces.	Dividends.
New Chum Goldfield	12,962	12,960	£20,800
Great Extd. Hustler's	10,964	8,970	16,150
South New Moon	19,287	8,285	12,800
Central R., W., & B.	22,976	5,707	8,000
Hercules & Energetic	6,469	3,719	7,437
Ironbark	13,995	4,730	6,198
Carlisle	19,306	5,660	5,818
Johnson's Reef	23,220	7,253	5,600
Golden Pyke	13,239	5,771	5,600
United Hustler's & Redan	7,652	3,948	5,391
Cornish United	7,639	3,130	4,131
Koch's Pioneer	10,122	4,121	3,688
North Bendigo	10,806	2,282	3,600
South Garden	3,321	2,075	3,600
Great Northern	14,315	4,310	2,775
Ida	4,173	2,874	2,400
Golden Age	5,017	2,257	2,138
Clarence United	15,553	4,842	1,875
Princess Dagmar	4,717	2,066	1,693
Virginia	26,345	5,239	1,350
Suffolk United	2,383	2,092	1,005
Constellation	3,195	1,241	755
New Gwynne	6,954	1,696	700
Totals	272,420	102,648	£126,879

Western Australia.—The rally noted in the 1913 gold returns was not maintained in 1914. In January, 1914, the production showed an

increase of 1480 fine ounces, as compared with January, 1913, but the succeeding months all showed a decrease. The total output is estimated at $26,186,750, as compared with $27,907,985 in 1913. Drought and market depression brought prospecting to a standstill. Four mines alone are responsible for a shortage of $1,780,000, namely, Golden Horse-Shoe, $630,000; Victorious, $550,000; Ivanhoe, $450,000; Bullfinch, $150,000; and smaller declines have been made by others. Against this the Edna May, which produced only $210,000 in 1913, increased its output during 1914 by $650,000, to $860,000. The outlook at present is not in favor of any increase in production.

COMPARATIVE STATEMENT OF GOLD PRODUCTION OF WESTERN AUSTRALIA FOR THE YEARS 1907 TO 1913.

	1908.	1909.	1910.	1911.	1912.	1913.	1914.
Tons treated (2240 lb.) ..	3,081,824	3,105,004	2,884,298	2,735,943	2,688,868	2,787,361	2,702,096
Gold yield (fine oz.).....	1,596,091	1,576,406	1,422,231	1,338,987	1,267,845	1,299,089	1,214,229
Value of yield(£).....	6,779,763	6,696,146	6,041,254	5,687,625	5,385,462	5,518,179	5,157,760
Value of yield per ton (in shillings).....	43.9	43.1	41.9	41.6	40.1	39.6	38.2
Total number of men employed (exclusive of alluvial diggers and prospectors).....	15,130	16,007	15,471	14,794	13,204	13,020	11,722
Profits distributed(£)....	1,487,303	1,358,088	1,028,393	826,976	814,092	906,797	799,383
Profits per ton treated (in shillings).....	9.7	8.7	7.1	6.0	6.0	6.5	5.9

Working costs per ton of 2000 lb.: 1908, 19s. 3d.; 1909, 19s. 11.5d.; 1910, 20s. 1d; 1911, 20s.; 1912, 19s. 3d.; 1913, 19s. 6.6d.

The gold production for the first 10 months of 1914, as reported to the Mines Department, was 1,005,576 fine ounces, valued at £4,271,418. Dividends paid for the whole year 1914 amounted to £786,733.

During the year ended September 30, 1914, the Great Boulder Perseverance milled 63,097 tons of ore, yielding 16,283 oz. gold and 3135 oz. silver, worth $336,000. Working costs were $4.25 per ton, and the profit was $44,000. Broken ore in the stopes amounted to 230,440 tons, assaying to $5.76 per ton.

At the Lake View and Star mines the mill treated 216,043 tons of ore averaging $6.52 per ton. Cost per ton was as follows: development, $0.40; mining, $1.24; milling, $2.23; general, $0.18; realization of bullion, $0.04; total $4.49.

During the year the Sons of Gwalia mill treated 160,964 tons yielding $1,257,500, against 162,101 tons and $1,267,000 in 1913. The profit was $383,200, compared with $327,900. Since September, 1914, the quarterly dividend has been reduced to $45,600, against $91,200 paid previously. The cost per ton milled was distributed as follows: development, $10.70; mining, $1.16; milling, $1.67; general, $0.39; bullion realization, $0.06; total, $5.42.

algurli did 2778 ft. of diamond drilling on and below the 1850 but discovered nothing encouraging. It is now considered e that any profitable ore will be found at greater depths than ed. During the year ended July 31, 1914, the company treated ns of ore for a yield of £255,748. Estimated ore reserves are ns, as against 250,000 tons for the preceding year. Compara- s for 1914 and 1913 are given below:

	1914.	1913.
.....	127,870	128,415
.....	£2 3s. 3.25d.	£2 2s. 8.46d.
.....	£2 0s. 0.01d.	£1 19s. 9.5d.
.....	19s. 11.37d.	19s. 10.5d.
.....	£255,748	£255,490
.....	£128,210	£127,879

ack Range mine of the Yuanmi Gold Mines company is prac- austed, according to the report of June 30, 1914. The Yuanmi mill crushed 40,135 tons of oxide ore, and the Krupp ball-mill, s of sulphide ore. An Edwards furnace roasted the latter acuum-filter plant handled the joint pulp, the average recovery 3 per cent. The stamps averaged 9.93 tons per day. The Black stamps averaged 8.75 tons, crushing a total of 54,460 tons. By tion, leaching sand, and vacuum-filtering slime, a total extrac- 27 per cent. was made.

t the Yuanmi were: mining, $2.45 per ton; treatment, $2.10; arges, $0.11; retreatment, $0.05; total, $4.71. At the Oroya ge: mining, $3.57; treatment, $1.84; bullion charges, $0.11; t, $0.10; total, $5.62. The dividend rate has fallen from 12½ nt.

aland.—The year 1914 was an unfortunate one for the mining f New Zealand, as the European war aggravated a depression been produced by the strike at the end of 1913. The most ct of the stringency of the money market was that shareholders pay assessments, with the result of stopping many operations. ping operations were stopped in October by the Thames Drain- , which had the effect of stopping operations in the crosscut at which no less than $240,000 has been spent. The suspension k will cause an almost total loss of this amount, as the filling of gs will deter other organizations from facing the cost of un-

rd quarterly report of the Consolidated Gold Fields company, n the South Island, contains the following data:

	Wealth of Nations.	Blackwater.	Progress.
Development, feet	686	719	1,220
Ore treated, tons	6,800	13,647	7,220
Yield per ton	$7.64	$8.79	$5.98
Cost per ton	$4.48	$5.28	$4.90
Operating profit	$22,500	$49,000	$8,600

The total working profit was $80,100, but shaft sinking, development, prospecting, and experiments cost $57,600, leaving a net profit of $22,500. A dividend of 5 per cent. (24 cts. per share) was paid on the Blackwater company's shares.

The real mining work on the peninsula is in Ohinemuri County. The Waihi has produced a regular monthly output of gold and silver worth $120,000, paying quartery dividends of 25 cts. per share. Better grade ore has been opened in the Waihi Grand Junction, and a dividend of 35 cts. per share was paid in November. The scheme to prospect the 6 miles between Waihi and the coast by a long adit and crosscuts has fallen through, owing to the war. The Waihi Reefs and the Waihi Consolidated have been amalgamated and will sink to 1200 ft. to cut the Waihi lode system. At Karangahake, 9 miles away, the Talisman has yielded about $110,000 per month, the ore averaging about $24 per ton. The Crown mine, which adjoins the Talisman, and has produced $3,900,000 to date, had to suspend work owing to the lack of funds for development. Ohinemuri County has produced bullion worth $72,000,000, of which $28,000,000 has been paid in dividends.

The value of the gold mining industry to the Auckland province is shown by the fact that the total output of bullion from 1857 to the end of last year was $106,000,000, the total yield for the whole Dominion for the same period being $394,000,000.

North America

Canada.—The principal gold- and silver-producing districts of the Dominion are in Ontario, British Columbia, and the Yukon. Ontario is the main silver producer, the mines at Cobalt continuing to turn out by far the largest proportion of the total silver output. The same province has also become an important factor in the gold production by reason of the developments at Porcupine. In British Columbia there is a considerable production of gold and silver as the result of lead and copper smelting. Yukon gold production is from placer mining. Details of the different districts are given on succeeding pages.

The preliminary estimate of the value of Canada's mineral production for 1914, as made by John McLeish, of the Department of Mines,

is $128,475,499, as compared with $145,634,812 in 1913, a decrease of 11.8 per cent. Gold produced in 1914 amounted to 770,374 oz., valued at $15,925,044; in 1913 the quantity was 802,973 oz., valued at $16,598,923. The falling off in the production of the metals is ascribable in large measure to the war. Especially is this true in the case of silver, of which 27,544,231 oz. was produced in 1914, as against 31,845,803 oz. in 1913.

Of the 1914 gold production, about $5,695,508 was derived from placer and alluvial mining; $6,050,690 in bullion from milling ores and $4,228,846 from smelter products. Compared with those for 1913, these figures indicate an increase in gold produced from milling ores, and a decrease in both placer and smelter production. The increase in gold from milling ores was largely from the Porcupine district of Ontario. The Yukon production shows a falling off of $721,384, the total in 1914 being $5,125,396. The total amount on which royalty was paid was 309,691 oz., as against 352,900 oz. in 1913 Exports of gold-bearing dust, nuggets, gold in ore, etc., in 1914, were valued at $15,242,200.

The general falling off in the production of metals in Canada in 1914 is attributed largely to the war. Especially is this true in the case of silver, of which 27,544,231 oz. was produced in 1914, as against 31,845,803 oz. in 1913. Of the total production, 88 per cent. is credited to Ontario, of which 67.7 per cent. was recovered within the province in the form of bullion.

Exports of silver in ore and silver bullion were 28,020,089 oz., valued at $15,584,813. Imports of silver in bars, blocks, etc., were valued at $629.279.

British Columbia.—The value of the gold production for 1914 is estimated by the Provincial Mineralogist at $5,177,343, of which $524,000 is credited to placer workings and $4,653,343 to smelting and milling. In 1913 the total production was valued at $6,149,027, being $510,000 from placer work and $5,639,027 from smelters and mills.

The silver production was about 3,212,111 oz. in 1914, as compared with 3,312,343 oz. in 1913.

Smelting companies ceased operations altogether for a while, due to demoralized conditions resulting from the war.

According to the report of the Provincial Mineralogist, the Atlin division of the Cassiar district produced gold worth $322,000, equal to 61 per cent. of the provincial output. The Engineer mine's 2-stamp mill, on Taku arm, produced about $20,000 by amalgamation of a high-grade antimonial arsenide ore occurring in a quartz-calcite gangue. This ore assayed up to $6800 per ton in places.

In the Skeena division, the important property is the Granby com-

pany's copper mine at Anyox, where about 9,500,000 tons of 2.2 per cent. ore has been proved. The smelter, which was blown in on March 15, treated 260,000 tons to the end of 1914, containing 12,000,000 lb. copper, 2800 oz. gold and 130,000 oz. silver. The Granby Consolidated and Tonopah Belmont companies did a lot of work on Princess Royal Island.

In the east Kootenay district, the Sullivan group produced 35,500 tons of ore containing 24,183,000 lb. lead and 474,500 oz. silver. The west Kootenay region is still one of the most important in the province, and includes the Bluebell, Consolidated Mining & Smelting, and other mines in the Ainsworth division; Rambler-Cariboo, Slocan Star, Surprise, Standard (with a yield of 890,000 oz. silver, 12,000,000 lb. lead, and 4,000,000 lb. zinc), Van Roi, and others in the Slocan divisions; the Nelson division; and Trail Creek with an increase of $200,000 over the previous year, the Trail smelter's output being worth $6,000,662, although ore came from all of the divisions mentioned in the west Kootenay area.

The metal yield of the Boundary district was 83,830 oz. gold and 328,-276 oz. silver; decreases of 18 and 17 per cent. respectively, due to the closing of smelters, owing to the war. Apart from the Granby and British Columbia companies' operations, which are well known, the Jewel-Denero Mines, Ltd., 15-stamp mill, 8 miles from Greenwood, treated about 16,000 tons of ore, yielding 6500 oz. gold and 33,000 oz. silver.

In the Vancouver division the Britannia company milled 240,272 tons of ore containing 250 oz. gold, 70,000 oz. silver, and 12,000,000 lb. of copper. A large number of improvements were made to the equipment.

Dating from February 1, wages of the Granby Consolidated employees at Phoenix and Grand Forks were raised 10 per cent. When work was resumed in December a 25 per cent. reduction was made, and in January a 5 per cent. raise was given.

The completion of the Kootenay Central Ry. by the Canadian Pacific, extending from Golden on the main transcontinental line through the upper Columbia and Kootenay River Valleys to the Crow's Nest line at Covalli, will unquestionably tend to open up the silver-lead and other deposits in the Selkirk Mountains, the development of which has been retarded by their isolation.

The Consolidated Mining & Smelting Co. paid four dividends aggregating $474,012, during the year ended September 30, 1914. Expenditures to property account amounted to $283,422, and to plant account, $366,567. The total tonnage smelted at Trail was 374,771 tons, having a gross value of $6,000,662. The metals produced from this ore were as follows: Gold, 129,083 oz.; silver, 2,568,301 oz.; lead, 34, 617,318 lb.; copper, 3,645,997 lb. Development work totaled 33,146

ft. and diamond drilling, 28,896 ft. It is stated that the development at the Rossland mines and also at the Sullivan group is encouraging.

The British Columbia Copper Co. could not operate its smelter to full capacity owing to a shortage of custom ore. The furnaces were blown out August 23. Production amounted to 14,442 oz. gold and 63,501 oz. silver, in addition to copper. Ore reserves in the company's properties are estimated at 4,523,763 tons of the following grade: 1.54 per cent. copper, 0.013 oz. gold, and 0.14 oz. silver, per ton. Probable ore of the same grade amounts to 1,675,000 tons. The outlying ore-bodies contain 405,170 tons, carrying 1.54 per cent. copper; 0.103 oz. gold and 0.14 oz. silver per ton. Probable ore in this section is estimated at 345,000 tons of the same grade.

The Hedley Gold Mining Co. treated 78.494 tons of ore of average assay value of $10.80; extraction, 94 per cent. A hydro-electric power plant was constructed on the Similkameen River. Diamond drilling and other developments indicate ore reserves of quantity and grade equal to those of the previous year.

Ontario.—Progress in the Porcupine district was responsible for an increase of over a million dollars in the value of gold production, the output of the province being valued at $5,546,356. Cyaniding by continuous decantation seems to be gaining favor in the district, most of the mills adopting that process. The silver output of the province comes mainly from the Cobalt district, with some small additions from other places. Silver production of Ontario in 1914 is estimated at 24,215,926 oz., or 88 per cent. of the total production of Canada. In 1913 the Ontario silver production was 28,441,261 oz. The decrease in 1914 is attributable to the war.

Fatal accidents in Ontario mines in 1914 resulted in the death of 58 men, 29 underground, 9 in surface works, 5 in metallurgical works and 15 in quarries. Of the fatalities in mines, 3 were caused by falls of ground, 10 in shafts, 10 from explosions and 6 from miscellaneous causes.

The silver production of Cobalt for 1914 was lower, both in quantity and value, than in 1913. When war was declared in August, the price of silver fell and the market was cut off at the same time. This resulted in the closing of some mines and mills for periods ranging from 1 to 5 months. The total production is comprised in shipments of silver ore and concentrates and shipments of silver bullion. Bullion shipments in 1914 totaled 9,624,629 oz., valued at $5,254,097, as compared with 9,873,480 oz. in 1913, valued at $5,895,449. Nipissing contributed nearly 75 per cent. of the bullion, producing from company and custom ores 6,299,678 oz., valued at $3,469,526. Shipments of ore and concentrates fell off from 20,916 tons in 1913 to 18,220 tons in 1914.

Dividends paid by Cobalt mines in 1914, as reported by *The Daily Nugget*, were as follows:

Company.	1914.	To date.
Beaver	.....	$410,000
Buffalo	$280,000	2,807,000
City of Cobalt	.....	139,321
Cobalt Central	.....	192,345
Cobalt Silver Queen	.....	315,000
Coniagas	1,320,000	7,240,000
Crown Reserve	424,479	5,960,858
Cobalt Townsite	200,000	1,042,280
Casey-Cobalt	93,750	203,349
Cobalt Lake	150,000	465,000
Caribou-Cobalt	50,000	75,000
Foster	.....	45,774
Kerr Lake	600,000	5,520,000
La Rose	899,176	4,974,998
McKinley-Darragh	472,015	4,257,028
Nipissing	1,350,000	12,240,000
Mining Corp. of Canada	259,375	259,375
Right of Way	16,850	542,754
Peterson Lake	129,096	129,096
Seneca-Superior	335,218	645,993
Temiskaming & Hudson Bay	69,849	1,040,259
Temiskaming	.....	1,384,158
Trethewey	50,000	1,061,999
Wettlaufer	.....	637,465
Hollinger	1,170,000	2,610,000
Porcupine Crown	180,000	180,000
Total	$8,049,808	$55,359,611
La Rose (shared privately prior to May 1908)	.....	1,304,862
Private corporations (est.)	300,000	3,800,000
Total	$8,349,808	$60,364,473

Bullion produced by various companies at Cobalt in 1914 is listed below:

Company.	Ounces.	Value.
Bailey	1,354	$785
Beaver	9,849	5,004
Buffalo	912,250	500,013
Casey-Cobalt	2,567	1,344
City of Cobalt	27,342	15,534
Cobalt Comet	1,598	934
Cobalt Townsite	36,539	19,580
Crown Reserve	626,374	343,833
Dominion Reduction	726,398	405,585
Foster Cobalt	2,157	1,018
Hargreaves	794	415
Kerr Lake	407,239	183,970
La Rose	55,365	29,067
McKinley-Darragh	17,470	10,017
Nipissing and Customs	6,299,678	3,469,536
O'Brien	452,822	243,934
Penn Canadian	16,455	8,940
Temiskaming	6,164	3,553
Townsite-City	17,640	8,466
Trethewey	4,576	2,410
	9,624,631	$5,254,098

Nipissing Mines Co. produced 4,689,333 oz. silver, of a gross value of $2,516,064. The production cost was 19.8 cts. per oz., which is 4.29 cts.

per oz. less than the cost in 1913. Ore reserves contain more than 10,000,000 oz. silver, the largest shown in the history of the company. The cost of production per ton of ore, based on 80,037 tons milled, was $11.60. Both the high-grade and low-grade mills worked to capacity throughout the year, at a reduced cost per ton of ore treated.

Mining cost at the Trethewey was $5.10 per ton of ore; milling cost was $1.31 per ton. At the Temiskaming & Hudson Bay, mining cost was $3.08 per ton. The cost of silver produced was 25.2 cts. per oz., of which freight and smelter deductions amounted to 7.19 cts. Kerr Lake's silver cost was 24.86 cts. per oz., and Crown Reserve's 28.96 cts.

The principal companies operating at Porcupine are the Hollinger, Dome, Porcupine-Crown, McIntyre and Vipond. The metallurgical system at the Dome was changed to include sand leaching as well as slime treatment, the change being due to the development of the mine into a large low-grade proposition. The Hollinger greatly enlarged its milling facilities and also constructed a mill to treat the Acme ore.

The Dome company gradually increased its tonnage during 1914, from about 13,000 tons in January to 23,000 tons in December. At the same time the grade of ore fell from $8 per ton in January to $3.50 in December. During the latter half of the year the average grade was about $4 per ton. It is expected that the capacity will be brought up to about 28,000 tons per month.

The Hollinger continued its exceptional record, producing gold to the value of $2,688,355 from 208,936 tons of ore. Dividends amounted to $1,170,000. The total cost per ton of ore milled was $4.42, distributed as follows: Mining, $2.70; milling, $1.22; general, $0.50. No. 1 vein has been found to persist at the 800-ft. level. Diamond drilling has shown that there is no change in the characteristics of the ore-bodies at a depth of 1500 ft. The main shaft was down 550 ft.

The Porcupine-Crown treated 40,857 tons of $17.65 ore, recovering 97.26 per cent. by continuous decantation. The main vein was located at the 500-ft. level.

The Tough-Oakes mine in the Kirkland Lake district produced gold to the value of $117,644 from 3493 tons of mill ore worth $22.33 per ton, and 213 tons of smelting ore worth $351 per ton. A loss of $59,807 was incurred on the year's operations. A new 100-ton mill using the continuous decantation system is practically ready for work. Development work in the mine totaled 1477 ft., and ore reserves above 300 ft. are valued at $1,500,000. Dumps and tailings are reported worth $160,000. Extensive surface improvements were completed.

Yukon.—Gold production in 1914 showed a decrease of $721,384, as compared with 1913, the respective values being $5,125,396 and

$5,846,780. Royalty was paid on 309,691 oz. in 1914, as against 352,900 oz. in 1913. The Canadian Klondyke Mining Co. and the Yukon Gold Co. are the only producers of importance.

According to Emil E. Hurja, who published a series of articles on "Mining in the Far North" in the *Mining and Scientific Press*, over $180,000,000 in gold is credited to the Klondike, as the production since gold mining first started in the Yukon. The greatest single year's production was $22,275,000 in 1900. Primitive mining was with the pan, pick and shovel. Then came the rocker, followed by the open-cut methods and finally dredging.

The Canadian Klondyke Mining Co. operated its fleet of four bucket-elevator dredges in the Bonanza Basin, near Dawson, Yukon Territory, for about 9 months of 1914. No. 1 dredge has 7½-cu. ft. buckets, while the other three dredges have 16-cu. ft. buckets, though one of these has been increased to 17 cu. ft. by adding a few inches to the lip of the bucket. The dredging began on Mar. 28, and the first cleanup was on Apr. 4. All four dredges were operating at full capacity by about May 15, and the yields up to the middle of July were highly satisfactory, usually averaging over 3000 oz. per week. In the latter part of July a break in the power ditch caused an interruption to dredging, and another interruption occurred on Oct. 10, when dredge No. 2 sank, and was out of commission for the rest of the season; raising of the dredge was begun in December. Early in November there was another break in the power supply, due to ice, and dredge No. 1 was cleaned up for the season on Nov. 17. Dredges Nos. 3 and 4 were put in operation again at this time. No. 3 was shut down on Dec. 4, while dredge No. 4 operated until late in December. The season's cleanup to Dec. 12 was 66,189 oz.

Life of the ground in sight for the dredges is estimated at 18 years. Four miles of ground prospected contain 150,000,000 cu. yd. of gravel of average value of 22 cts. per cu. yd. Operation up to this time has shown a recovery of about 25 cts. per yd. at a working cost of 6 cts.

Some work was done in 1914 on the properties of the Canadian Klondyke's sister company, the North West Corporation, in the Indian River section; this included the stripping of the overburden and the acquisition of further claims to round out the property. Up to this date the earnings of the Canadian Klondyke have been applied to meet the interest on the bonds of the North West Corporation; to provide a preliminary plant to start gold production, a further £50,000 to £100,000 is required.

The Yukon Gold Co. operated eight dredges at Dawson, one at Iditarod, Alaska, and three in California. In addition to dredging, extensive hydraulic mining was carried on. The company earned and paid its

regular dividend of 6 per cent.; financed the purchase of two dredging properties in California; wrote off $843,215 of depreciation and amortization; and added $78,307 to surplus. The authorized capital stock has been reduced from $25,000,000 to $17,500,000. The Dawson dredging season in 1914 was 164 days, being limited in length by the operation of the hydro-electric power plant. The dredges mined 4,800,781 cu. yd. of gravel, producing $2,602,685, an average of 54.21 cts. per yd. The average cost, including depreciation, was 27.62 cts. per yd. Compared with the 1913 season, the results for 1914 show a decrease in yardage, gross value and net profit. The reduction in value was 19.92 cts. per cu. yd. Of the ground dug, 68.6 per cent. was frozen and had to be thawed. The thawing cost was reduced 1.39 cts. per cu. yd., and was lower than for any previous season. The Iditarod dredge handled 668,737 cu. yd., producing $739,631, an average of $1.10 per cu. yd. Operating cost was 50.2 cts. per yd., a decrease of 14.1 cts. compared with the previous year. In hydraulic operations, 3,241,641 cu. yd. was handled, producing $544,262 at a cost of $245,686. Working cost was 7.6 cts. per cu. yd., a decrease of 2.1 cts. under last season. Water duty was 6.02 cu. yd. per miner's inch. Summary of operations follows:

	Production.	Working Costs.	Operating Gain.
Dawson—dredges	$2,602,685.51	$1,326,080.75	$1,276,604.76
Dawson—hydraulics	544,262.15	245,685.95	298,576.20
Iditarod—dredge	739,630.74	335,824.77	403,805.97
California dredging	322,570.61	136,772.21	185,798.40
Miscellaneous operations	135,897.10	6,525.06	129,372.04
Total operations	$4,345,046.11	$2,050,888.74	$2,294,157.37
Non-operating income			18,969.01
Total income			$2,313,126.38

Ground on the Treadgold placers was cleared by ground sluicing. To July 1, on Dominion Creek, a total of 774,294 yd. had been cleaned; on Granville Creek, 790,173 yd.; and on Quartz Creek, 1,027,070 yd. The cost of removing the muck is about 3 cts. per yd., although it has been as high as 7.7 cts.

Considerable dissatisfaction exists relative to the Yukon placer mining regulations, in which frequent and rapid changes have been made since 1884. The incongruities existing give rise to much trouble and litigation, and recommendations have been made to Ottawa to have the laws improved.

An important contribution to Yukon mining literature was made by T. A. MacLean, of the Department of Mines, Canada, who published "Lode Mining in Yukon."

Mexico.—The chaotic conditions that have prevailed in this republic for a long time seriously hampered attempts at continuous mining in 1914. Business and finance are demoralized within the country, and comparatively few companies have been able to do anything. In some of the larger centers important producers have been able to operate irregularly, but in isolated sections, where only small concerns were mining, business has been brought to a standstill. Paper money of a variety of shapes and greater variety of value has flooded the country and made commercial transactions difficult and unsatisfactory. Transportation is difficult and unsafe, and the conditions have been unfavorable to the shipment of supplies into the country.

The gold production of the republic in 1914 is estimated at $18,185,000. No estimate can be placed on the silver production.

PRODUCTION OF GOLD AND SILVER IN MEXICO.
(Fiscal years ending June 30.)

Year.	Gold.		Silver.	
	Kilograms.	Pesos.	Kilograms.	Pesos.
1900-01	13,810	18,413,381	1,816,605	74,326,406
1901-02	14,706	19,607,967	1,772,724	72,530,983
1902-03	14,904	19,872,148	2,023,922	82,808,783
1903-04	17,082	22,775,815	2,013,383	82,377,546
1904-05	21,306	28,407,313	1,931,985	79,047,148
1905-06	27,307	36,409,368	1,849,956	75,605,605
1906-07	27,423	36,563,898	1,756,704	77,088,827
1907-08	30,395	40,527,185	2,151,014	85,366,904
1908-09	33,661	44,881,621	2,291,261	77,076,097
1909-10	36,222	48,295,508	2,257,363	76,371,884
1910-11	37,112	49,481,956	2,305,094	80,878,729
1911-12	36,415	48,553,632	2,493,731	89,628,435
1912-13	29,843	39,591,427	2,280,000	91,293,652

NOTE.—1 kg. = 32.15 oz. 1 Peso = $0.50 U. S. currency.

The American Smelting & Refining Co.[1] reports that all operations were suspended on the occupation of Vera Cruz, but were resumed later at several properties. Since that time operations have been spasmodic and plants have been started and closed again.

The smelting plants in Mexico number seven, four of which belong to the American Smelting & Refining Co. The combined annual capacity of the 45 furnaces is 2,059,000 tons.

Company.		Furnaces.	Annual Capacity.
American Smelting & Refining Co.	Monterey	10	475,000
American Smelting & Refining Co.	Aguascalientes	2	100,000
American Smelting & Refining Co.	Chihuahua	5	274,000
American Smelters Securities Co.	Velardena	3	140,000
Compania Metalurgica Mexicana	San Luis Potosi	11	385,000
Compania Metalurgica de Torreon	Torreon	8	360,000
Compania Minera de Peñoles	Mapimi	6	325,000
Total		45	2,059,000

[1] *Mining Journal*, Nov. 28, 1914.

The plant at Chihuahua was in operation for part of the year and received ores from the Santa Eulalia district. The Torreon smelter also resumed operations at reduced capacity.

In Sonora, the Tigre, at Esqueda, was forced to close for seven days at the time of the occupation of Vera Cruz, but otherwise has been able to operate continually. Operations at the Palmarejo & Mexican Gold-fields in Zacatecas were halted by political troubles, and resumption of work is indefinitely postponed. At El Oro the mills were closed in April, and only mine development work was done until October, when some of the mills again resumed operations.

The output for the El Oro mines for the year will be approximately as follows:

	Tons.	Production.
El Oro M. & R. Co.	229,200	$1,317,800
Esperanza	173,800	1,060,000
Mexico Mine	61,600	868,000
Dos Estrellas	.....	2,180,600
La Lucha	4,500	73,700
Total	469,100	$5,500,100

The output in 1913 was 829,700 tons with a production value of $13,002,450.

At Pachuca the Americans were forced to leave in April, but the Real del Monte continued operations with its Mexican staff, milling not less than 700 tons per day. The American staff returned in September, and operations were continued on a restricted scale, owing to shortage of supplies. The results of development work during the year are reported satisfactory. Additions to mills have been completed, and they now have a rated capacity of 60,000 tons a month.

The Santa Gertrudis ceased operations on April 21, and resumed again on July 6. For the year ended June 30, 1913, the mining cost, exclusive of depreciation, was 12s. 4d., as against 17s. 10d. for the preceding year. The reduction was due in large part to the favorable conditions of exchange, and it is considered that when normal conditions are resumed in Mexico the costs will be advanced by about 25 per cent. No prospecting was undertaken, but development was carried on vigorously. The Guadalupe mill was closed during the year. Quicksilver amounting to 8.759 tons was recovered from the old patio. The new mill treated 293,836 tons of ore, of assay value of 33s. 11d. per ton. Bullion recovery was 92.78 per cent. or 31s. 2d. per ton. Metals produced: gold, 16,587 oz.; silver, 3,182,341 oz.

At Guanajuato there was a shortage of supplies, but most of the com-

panies continued operations. The Guanajuato Consolidated ran 80 stamps up to April, but only 40 after that time. The Bustos mill and Flores cyanide plant of the Guanajuato Reduction Co. operated continuously. The Guanajuato Development Co. operated its principal mines and mills, but reduced development and non-productive work to a minimum. The Hostotipaquillo district of Jalisco has been closed since April, only a little desultory work being done at various times.

Central America

Producing mines in this part of the continent were operated about as usual during 1914, the European war making little difference in conditions except in the case of new enterprises. The latter were held in abeyance, and development probably will be resumed when financial conditions improve.

Costa Rica.—The Aguacate mines continued development near San Mateo, and encountered a bonanza from which a yield of a million dollars is assured. The ore milled in November averaged $28 per ton. The Abangarez Goldfields operated as usual until about May, when trouble was had with high grading and pilfering of precipitate. Attempts to check the losses met with resistance, and in June military forces were necessary to maintain order. The company finally ceased operations until effective legal measures could be enforced to stop the stealing. During the last half of the year, only development work was done. La Union mine of the Panama & Costa Rica Mining Co. produced steadily at the rate of 3000 tons a month, the ore being treated by amalgamation and cyanidation.

Honduras.—The New York & Honduras Rosario Mining Co. continued its successful operations at San Juancito. The treatment of 108,000 tons of ore yielded approximately 14,000 oz. gold and 1,818,000 oz. silver. The company continued its geological survey of the district. Operations were on a larger basis in 1914 than in 1913, the duty of the 1850-lb. stamps being increased to 17 tons per day through three-mesh. The Socorro Gold & Silver Mine, Ltd., at Valle de Angeles, started its 30-ton mill about May and continued throughout the year. Some placer operations were under way in the department of Olancho.

Nicaragua.—The Central American Goldfields Syndicate, Ltd., which had options on the Bonanza, Mars, Siempre Viva and other mines in the Pis Pis district, ceased operations during 1914 on account of title difficulties. The Tonopah Mining Co., of Nevada, had an option on the property of the Panama Mining Co. up to February, 1915. If the option is exercised a new company will be formed to take over the property, and

40 per cent. of the stock of this new company will be given the Panama Mining Co. for distribution. A complication has arisen in the form of a suit by Rolando Kuehn, a former president of the Panama Mining Co., to restrain a conveyance of the property to the Tonopah Mining Co., alleging fraud and neglect on the part of the officials of the Panama company. The Babilonia Gold Mines operated a cyanide plant during the year and the Javali & Escandalo began the construction of a similar plant.

Salvador.—The two principal operators were the Butters Salvador Mines, Ltd., at San Sebastian, and the Butters Divisadero Co., at Divisadero. Production at San Sebastian was at the rate of about $60,000 per month from 3000 tons of ore. The output at Divisadero was increased and new equipment was added at mine and mill.

South America

The northern countries of this continent, which produce more gold, were not so much affected by the war as were the countries on the west coast, according to the *Engineering and Mining Journal.* In the latter region the mining industry was in a comatose condition in the latter half of 1914. The gold production of the continent probably did not vary much from that in 1913 and 1912, when the value was about $14,550,000.

Bolivia.—The moratorium which was declared on the outbreak of the war was extended for 90 days from January 1, 1915. According to F. C. Lincoln, in the *Engineering and Mining Journal*, attempts to work the famous old placers of Bolivia by modern methods have met with disheartening failures. The two producing lode mines in the country are the Olla de Oro and the Incaoro. Both were worked by the ancient Spaniards. The Olla de Oro ore deposits are of the saddle-reef type, composed mainly of quartz in which free gold is sometimes visible. Gold-bearing pyrite, pyrrhotite and arsenopyrite also occur in the reefs. Mining is done by contract. Holes are paid for at the rate of 1.6 cts. per in. in slate and 3.2 cts. when in quartz. Drifting and raising costs $16 per linear meter, everything but the steel being furnished by the contractor. Miners not working on contract receive from $0.80 to $1.20 per day; helpers, $0.60 to $0.80; outside men, $0.60 and under. The Olla de Oro has a 50-ton amalgamating mill, plating about $5 per ton of ore, with the residues running about $2.50, mostly in the sulphides. A new mill under construction will be equipped with concentrating machinery. The Incaoro 50-ton amalgamating mill plates about $5 per ton, and can make concentrates worth from $16 to $150 per ton.

Brazil.—The St. John del Rey has proved its ore body to be 1150 ft.

long on horizon 18, 5200 ft. below the outcrop. The amount and assay value of the ore at this horizon is about the same as above. The working cost has been slightly increased due to higher rates for freight and insurance caused by the war. During the 6 months ended August 31, 1914, 95,000 tons of ore was milled, yielding gold worth £225,514, or 47s. 5d. per ton. Royalty was £12,876 and working cost £154,064; total, £166,940, or 35s. 2d. per ton. £5000 was paid in dividends on the preference shares and £20,584 on ordinary shares. The labor shortage has disappeared and the mine now has a full complement of labor. The Ouro Preto, during the year ended June, 1914, treated 66,139 tons of ore yielding 22,601 oz. gold which realized £90,433. The yield per ton was £1 7s. 4¼d., while costs were £1 6s. 6¾d. Total profit was £1660. The year was an abnormally poor one owing to working a poor zone in the mine. The low returns are considered only temporary and the mine is regarded as having a good future.

Colombia.—The Pato dredging property of the Oroville Dredging Co. had a most successful year. Production was $848,114 from 1,400,240 cu. yd., an average of 60.5 cts. per yd. According to W. A. Prichard, who made an extensive investigation of the property, the average yield from the time the dredge reached the prospected area was double the estimated average yield of 3 cts. This is ascribed to failure to drill at sufficiently close intervals, thereby underestimating the value of an unusually rich strip of ground. As a result of 12 months' examination of the Pato property, during which time 291 Empire hand-drill prospect holes and six shafts were sunk with the object of extending and checking the prospected areas, the prospected area undredged at Oct. 1, 1914, is estimated at 528¾ acres of an average depth of 26.3 ft., and of an average recovery value of 31.6 cts. per cu. yd. This area is calculated to contain 22,419,490 cu. yd. of a gross value of $7,092,100. The field operating cost of dredging, on the basis of one dredge on Pato and one on Nechí, after 12 months from Oct. 1, 1914, and two on Pato after 18 months from that date, is $1,744,462; estimated net returns, $5,347,638, or $1,100,000, approximately.

The yardage of the Pato dredge varies with the amount of clay in the ground. During July and August, 1914, the material handled was 128,488 and 139,547 cu. yd., respectively. The cost per cu. yd. was 10.25 cts. and 11.52 cts., respectively. After the Nechí dredge begins operations, bearing its proportion of overhead expenses, the costs for Pato should not exceed 8 cts. per cu. yd. An additional dredge is recommended for the Pato.

According to the 1914 report of the Consolidated Gold Fields of South Africa, the prospecting operations carried on at the Anglo-Colombian

roperty, near Novita in Colombia, have disclosed over 27,000,000 cu. d. of dredgeable gravel containing gold and platinum. The dredge as been shipped and it is anticipated that it will be at work in April, 1915. n addition to the dredging ground, an area containing 8,500,000 cu. yd. as been proved and may be hydraulicked or let on tribute to the natives.

The principal lode mining operations are in the departments of ntioquia, Caldas, Tolima and Bolivar. In Antioquia the Zancudo ine in the Titiribi district produced about $30,000 per month, the value the ore being about $15 per ton, two-thirds being in silver and one-ird gold. The Brittania silver mine shipped its product in the form of oncentrates. The Frontino & Bolivia milled about 2000 tons a month r a monthly yield of about $70,000. In the department of Caldas, ie Marmata and the Cascada were the principal producers. At Fresno, the department of Tolima, the Frias silver mine, operated by the olima Mining Co., produced about 16,000 tons which, after hand pick-g and concentrating, yielded about 560,000 oz. of silver and lead to the alue of about $22,000. The value of mineral exports from Colombia in 913 was reported by the *Pan-American Union Bulletin*, as $5,514,600, f which over $4,100,000 was gold and $583,995 was platinum. The old production was about equally divided between placer and lode mines.

The government has decreed the coinage of $2,000,000 in silver coins f the denominations of 1 peso and ½ peso.

Ecuador.—The South American Development Co., in the district of aruma, has the only active gold mine in the country. The gold produc-ion for 1914 is estimated at about $300,000. The value of gold bars, ullion and dust exported during the first 6 months of 1913 and 1914 s given as $190,107 and $140,939.

The Guianas.—Mining was active and the gold production probably xceeded that of 1913. The Mataroni dredge on the Riviere Approague as added to the fleet of gold boats. In Dutch Guiana the Guiana-allao Gold Mining Co. increased its mining rights to cover an area of 000 acres. Gold quartz veins are known to occur in Surinam and sev-ral attempts have been made to open them. In British Guiana the old shipments for the first half year exceeded those of the same period n 1913. The gold output to Nov. 5, 1914, was $937,636, compared with 1,167,246 in the same period of 1913.

Peru.—The New Chuquitambo, in Cerro de Pasco, ran steadily, reating in October 1641 tons of ore with a recovery of 10,150 gm. of old. The Inca Mining Co. completed its new mill at the Santa Domingo ine, but it was not operated. Placer production was small. About 8,000 cu. yd. was washed at Aporoma for a recovery of 7.8d. per cu. yd. An examination of placer deposits in Arequipa was begun late in

1914 in the interests of an American concern. Much work in the Casapalca district was suspended on the outbreak of the war. The San Antonio mine continues to ship ore to the Casapalca smelting works. Electric haulage is to be adopted at the Carlos Francisco mine, the principal property in the Casapalca district. An aerial tramway 6000 ft. long was constructed last year to bring low-grade dump ore from the Carlos Francisco to the mill. The Casapalca smelting works has been doubled in capacity. Two blast furnaces, two converters, and a Dwight-Lloyd sintering plant are in operation. When normal conditions return, the output of Casapalca will exceed anything known in the past. On August 27, 1914, the government authorized the national Mint, for a period of 30 days, to coin soles ($0.48) and half-soles of any silver offered by individuals.

EUROPE

The principal production of gold and silver in Europe comes from Russia. The extremely unsettled conditions among European countries in the latter part of 1914 prevent giving many data. The gold production in 1914 for Europe, excluding Russia, is estimated by the *Mining Magazine* at £500,000. The Russian output is estimated at £5,500,000.

Austria.—The output of mining and metallurgical products for 1913 is officially reported in *Glückauf*, as follows: Gold ore, 35,994 metric tons; silver ore, 19,937 metric tons; gold, 284 kg.; silver, 54,000 kg. The total value of the mining output is placed at $74,284,485; the metallurgical products were valued at $36,321,750. Both classes of output showed an increase over those of 1912.

Russia.—Gold mining was interfered with during the last half of the year 1914 by shortage of labor when military forces were mobilized. In fact labor is reported to be growing constantly dearer in Russia, and this, coupled with the impoverishment of the gold deposits, has resulted in closing operations in many cases. The government's prohibition of the employment of yellow labor in the Amur district has retarded operations. The Lena Goldfields, Ltd., controls one of the world's greatest placer properties, located in the Irkutsk government of Siberia. This company holds 60 per cent. of the shares of the Lenskoi Gold Mining Co., which is the operating concern. The report for the year ended September 30, 1914, shows that a total of 873,633 cu. yd. of gravel was washed, yielding 370,210 oz. gold, valued at £1,381,993. Including purchased metal and gold in slag, the total was 399,111 oz., worth £1,489,881. The areas controlled by the Lenskoi have a recorded output of over £40,000,000 ($195,000,000). A higher recovery was made by adopting American methods, and an engineer from the United States is superintending other

changes. The cost of operation and Petrograd expenses was $7.13 per yd., a reduction from the previous year. Three classes of reserves are 2,194,890 cu. yd., valued at £3,595,000; 1,949,500 cu. yd., valued at £2,781,000; and 56,000,000 cu. yd., worth £5,113,000, respectively. The latter can be worked by hydraulicking. The estimated profit in these reserves is £3,633,700. At the end of the year there were 7636 men employed.

An interesting comparison between working the Bodaibinsky area by drifting and sluicing is given, showing the following results: by drifting, 1,270,000 cu. yd. averaging $5.23 per yd., giving a loss of £307,000, converted by adoption of the hydraulic method, treating 12,700,000 cu. yd. averaging 4.4 cts. per yd., into a profit of £852,000. The reserves mentioned by no means exhaust the possibilities in this area for sluicing, and extensive areas of bench gravels bordering the Bodaibo valley can be worked in this way also, without elevation of tailing.

The consulting engineer, C. W. Purington, estimates the annual loss of gold by theft at $500,000. It is proposed to reduce this loss as much as possible by substitution of machinery for hand labor and by building change houses and requiring miners to change clothes on leaving work.

The *Mining Journal* considers Russia a center of greater expectations in the mining world than any other country. This opinion is based on the known mineral resources, the success of recent metallurgical undertakings, and especially the accounts of the surprising richness of the Altai region. Gregor Mayer discussed the geology of Smeinogorsk in the Altai.

Gold and Silver Milling in 1914

By H. W. Fox

Introduction

The year 1914, on account of the European war and financial depression in the United States, has been quiet as far as new construction is concerned, and nothing new of great promise has been brought out. The use of continuous agitation has become almost standard practice where the type of agitator used makes it feasible, and reliance upon counter-current washing to avoid or minimize the work of filters seems established securely as a satisfactory method, and has been adopted in a large percentage of the new mills planned. Several filter plants also have changed to this method, either abandoning the filters or using them as dewaterers. This change has been accelerated by the filter litigation and the publication of data showing increased extraction at diminished costs. Better methods of solution handling and a clearer understanding

of chemical facts have removed some of the difficulties that have caused precipitation troubles in the past, and more attention is being paid to the importance of having solutions properly clarified. Aluminium is gaining in favor as a precipitant. The chemical side of cyaniding is attracting some interest resulting in some noteworthy gains, among which is the use of a reduction process in desulphurization in place of innumerable previous oxidizing processes.

The Treatment of Slimes

One of the direct results of the long drawn out litigation of the filter companies, and the resulting unsettled condition in which the royalty question was left, has been the attention that has been given to the development of the counter-current decantation system for the handling of slimes. This development has been one of the most interesting features of slime treatment brought forward during the past year. It seems to have been remarkably successful wherever tried, so much so that it is rare to find, at the present time, any mill using the filter to recover the dissolved metal only. Many of the new mills have been planned for its use alone, and have eliminated the filter entirely. In others, use has been made of it as an aid to the filter by reducing the dissolved values in the pulp to a minimum before going to the filter, and relegating the filter to the position of a dewatering machine for the reduction of the moisture contents of the pulp and to recover the cyanide left in the moisture. Some of the mills already built with extensive filter plants have found it advisable to set aside these installations and install the continuous counter-current decantation system in their place. This has been done with notable success at the Tom Reed mill at Oatman, Ariz., and at the Gold Road mill at Kingman, Ariz. Many other mills have made use of the system wholly or in part. Among the new mills using the continuous counter-current system alone and operating without any filter plant whatever may be mentioned the Porcupine McIntyre, Porcupine, Crown, Vipont, Acme portion of Hollinger, Porcupine district, Globe & Phoenix, Rhodesia, the Mogul in the Black Hills, and the Rochester mill at Rochester, Nev. It is being used with a filter plant at the new Commonwealth mill at Pearce, Ariz., New Reliance, Black Hills, the Nevada Hills at Fairview, Nev., the Buckhorn mill at Buckhorn, Nev., Tonopah Mining Co., and Tonopah Belmont at Millers, Nev., the Globe Consolidated at Dedrick, Calif., and at many others.

An extended discussion of this system is given by H. A. Megraw[1] in an article on the Development of Continuous Counter-current Decanta-

[1] *Eng. Min. Jour.*, 98, 648.

. He states that this process in slimes treatment, to replace or
lement the filter, is making notable headway. New mills are being
tructed to use it, and old ones are being re-arranged to take advantage
s economies. The ore must be properly prepared to take advantage
he highest efficiency obtainable, just as it must be prepared in any
r process. It must be carefully borne in mind that continuous
ter-current decantation was not designed to provide means for
lution of precious metal, but to provide a method for the simple and
omical separation of the dissolved metals from the solids. Not-
standing the fact just mentioned, it will be found almost impossible
ass a pulp, whatever its previous agitation, through a continuous
ter-current decantation system without accomplishing some addi-
l dissolution of the metals, small though it may be. This is so true
some operators, who are concerned in the treatment of clean free-gold
of low value, have believed that the decantation system was all that
necessary to dissolve the economically maximum portion of the
. Most of these have discovered that agitation was beneficial after
ut it is still true that the changes of solution incident to continuous
ntation tend strongly toward the dissolution of further quantities of
l. To take advantage of this secondary function to the fullest
ble extent, it is clearly desirable that the pulp should be of even
the essential for maximum dissolution in continuous agitation
ms. The principle of the process is exceedingly simple. It is the
that slimes may be dewatered by allowing them to settle quietly
gh the solution, and to decant off the solution. The settled slime
t, of course, thoroughly or entirely dewatered, but retains a per-
ge of its original solution, the amount depending upon several
rs, among which may be mentioned the specific gravity of the slime
, the specific gravity of the solution from which it is settled, size of
lime particles, temperature, and the acidity or alkalinity of the
ion. These factors vary, and their effects upon settlement vary
the different slimes and solution handled, so that no general rules
be laid down for operation. A slime thus settled may be reduced
out 30 to 50 per cent. of moisture. When the original pulp contains
5 tons of solution to one of solids, it will be seen that the removal of
ion has been considerable. If the thickened slime be then mixed
other solution up to the point of original dilution, or less in many
, the character of the solution is changed, the new solution being
ted slightly by the small percentage remaining in the thickened
es. If this process is repeated, it will be readily seen that the small
tity of solution remaining in the thickened portion will be quite
rent from that remaining in the original thickened portion, having

been increased or decreased in value, cyanide, or whatever the solution may contain, accordingly as the newly added solution differs from the original. If the newly added solution is water, then the solution in the mixture will be of low value. If water were added not only once, but two or three times, it may be easily seen that the value of the solution remaining in the thickened pulp would approximate nothing, and for practical purposes could be considered as such. But in practice it is quite evident that it would be impracticable to use water dilution as many times as would be necessary to reduce the value of the solution to an inconsiderable figure. This difficulty is surmounted by using barren solution as a diluent, and introducing water at the last only in such amounts as will make up for the loss of moisture in the process. The advent of continuous decanting machines, in which decantation may be carried on without interruptions of any kind, has assisted to improve the efficiency of the process, and consequently they have been adopted in well-designed mills. The Dorr thickener is the machine which has done most to bring about successful treatment, and is the one most generally used in the new installations. Agitation of slimes to recover the gold or silver, or both, may be performed entirely before counter-current decantation, or it may be a part of the process, or it may be omitted altogether, as it is in some mills, depending upon the contact between the slimes and the solution in passing through the thickener series to recover the maximum amount of the metals. The latter system is sometimes employed with clean siliceous gold ores in which the metal is fine, rather readily dissolved in cyanide, and where the solution is not required to be of great strength. In treating silver ores, the solution must be of much higher strength and requires a considerable length of time to accomplish dissolution, consequently an agitation system is usually resorted to before beginning the continuous counter-current decantation series. In many cases this series has to be assisted by a dewatering filter after the decantation has been completed, since the cyanide in the final decantation-thickened product retains sufficient value to be worth saving through a simple filtering process. In this case, of course, the filter need not be an elaborate one nor one susceptible of washing, a simple dewatering being the only requirement. When filters are used in connection with counter-current decantation, a much more rudimentary plant may serve, for the reasons already mentioned. The sole object is to save the cyanide contained in the water, and the water itself where it is scarce and expensive. The author gives a detailed description of the process as used in the Hollinger and Porcupine mills at Porcupine, Ont., the Tom Reed and Gold Road mills in Arizona. In the description of the Tom Reed mill, a number of flow sheets are given showing the saving that is

made by various modifications of the process. In this plant a total saving of 99.85 per cent. of the dissolved values is made by the continuous counter-current system.

Another article by H. E. Megraw[1] treats in a very thorough manner on the filtering of slimes in cyanidation. He describes the early attempts at handling slimes by decantation and in the old-style plate and frame filter press. He traces the improvements that have been made since the introduction of the vacuum filter and shows the evolution of the filter up to the present improved type of drum filter. He discusses at length the sluicing filter press of the Merrill type and the growing importance of counter-current decantation. He concludes that more recent practice favors continuous processes, leaning toward drum filters and counter-current decantation or a combination of both, the last being especially efficacious in treating silver ores.

C. E. Rhodes and A. B. Myers[2] describe the construction and operation of the Burt revolving filter at the El Oro Mining & Railway Co., Ltd. This filter, which consists of a revolving steel shell lined with filter mat, is treating slimes at a cost of $0.049 per ton. High extraction of the dissolved values is claimed, and the cake can be discharged with a moisture content of from 19 to 25 per cent. H. A. Morrison and H. G. Thompson describe the operation of the Oliver filter in the Globe mill at Dedrick, Calif.

Among the more recent developments at the concentrate cyanide plant of the Alaska Treadwell Gold Mining Co. that have tended to lower operating costs and increase the extraction has been the adoption of the Treadwell self-sluicing type of filter press. This press is described by W. P. Lass in an article on the New Filtering Process at the Treadwell Cyanide Plant.[3] The original equipment of presses consisted of two type 1B 50-ton Kelly filter presses. The principal objection to these was the labor in operating and repairing. It was accordingly decided to build a self-sluicing drum type of filter. Two of these presses have now been in continuous operation for the past 9 months, one for clarifying solutions and the other for filtering concentrates. Their complete success has improved greatly the efficiency of the whole plant. The plant, which formerly required two men on each of the three shifts to discharge 100 tons of material and clarify 300 tons of solution, is now being operated on two shifts by part of the time of one attendant. However, it is not only the operating labor but the upkeep and repair costs that have been materially reduced. The filter consists of a steel cylinder 8 ft. in diam. and 16 ft. long, lined on the inside with concrete

[1] *Eng. Min. Jour.*, **97**, 1057.
[2] *Eng. Min. Jour.*, **97**, 1185.
[3] *Min. Press*, **110**, 256.

to form a square box to receive the filter leaves, without leaving void spaces which would require a larger amount of excess pulp or solution in the operation of filling or discharging. The filter was made round, as the simplest and most economical means of obtaining the required strength. The heads of the press are boiler-plate, reinforced with I-beams to withstand a pressure of 200 tons. The press is filled and washed in a manner very similar to the way a Kelly press is operated, and the cake is reduced to about 8 per cent. moisture by blowing with compressed air, when it is ready to be discharged. Water is now turned on through a revolving spray pipe, operated by an electric motor, and running through the under side of the press in such a manner as to wash off the cake and sluice out the residue through 6-in. pipes leading from the lower side at each end of the press. The time of operation of a complete cycle is 160 min. The time allowed to take off the head of the press, remove the old leaves and place a complete set of new ones ready for operation is 4 hr. or one-half shift, although, if occasion demands, the press may be dressed in less than 2 hr. One of the important advantages of this self-sluicing press is that it may also be used as a treatment press, and under certain conditions may entirely dispense with agitation or treatment tanks. Sand deposited on the filter may be given acid washes, alkali treatment, aeration, cyanide treatment, or water washes, without removing the cake from the filter leaves. No pumps are used in connection with this filter, and the absence of any vacuum is one of the important features. The simplicity of the apparatus makes the construction costs compare favorably with any press of equal capacity.

A new modification of the drum type of filter has been patented by Henry Alinder.[1] H. E. West gives some practical advice, aided with sketches, as to pipe arrangement for sand and slime pumps.[2] Donald F. Irvin describes[3] the method of continuous agitation used at El Tigre, Sonora, in Pachuca tanks. By using modifications of the transfer pipes and by use of additional air pipes for cleaning away accumulated sand, no trouble was experienced in the continuous operation of the installation. This article was discussed by F. J. Girard.[4] G. H. Clevenger[5] discusses pulp constants. He treats of the errors that come into the calculations of dry slimes where the specific gravity of the mill solution is taken as one. He gives methods of calculation for determining the specific gravity of pulps and detailed tables for the calculation of the amount of dry slimes in pulps of different gravities. Reference should be made to this very valuable and interesting article for details. L. R. Benjamin,[6] in "Dissolved Gold in Slimes Residues," discusses the low results so often

[1] *Met. Chem. Eng.*, **12**, 195.
[2] *Eng., Min. Jour.*, **97**, 569.
[3] *Min. Sci. Press*, **108**, 571.
[4] *Min. Sci. Press*, **108**, 817.
[5] *Eng. Min. Jour.*, **98**, 1097.
[6] *Mon. Jour. of Mines* (Australia), **13**, 235.

found in the assay of slime pulp and gives a method of treatment prior to assaying that overcomes the tendency to low results.

In an article on ore classification for cyanidation, H. A. Megraw[1] gives some interesting observations on classification. He thinks that too little study is given this most important detail of the cyanide process by operators. He describes hydraulic, mechanical, and screen classification as practised at various mills. He concludes that the mechanical devices are most popular now, although screens are valuable and would be more used if they were not so costly to operate. Reference should be made to the original for details of this valuable paper.

The merits of the "Combined Cyanide and Other Processes" as against the straight cyanide is discussed by H. A. Megraw.[2] He gives at length a comparison of the two schemes as applied to a Mexican silver mill. James Johnson[3] treats of the conclusions arrived at by the Nipissing Co. in their comparison of straight cyanide as against combined cyanide and concentration. The subject is also discussed by G. H. Clevenger[4] and Thomas Crowe.[5]

Precipitation and the Treatment of Precipitates

Better methods of solution handling and a clearer understanding of chemical facts have removed many of the difficulties that have caused precipitating troubles in the past. However, new problems still have to be faced, as the more improved methods of cyanidation are constantly bringing many rebellious ores within the range of economical treatment, with the consequent introduction into the solutions of compounds not formerly met with in the earlier practice. Aluminium precipitation is being used with good results in a few special cases, but zinc, and especially zinc dust, is still the almost universal precipitating agent. Practically all of the new installations have been equipped with zinc-dust apparatus, and many of the older mills have replaced their zinc boxes with presses for the use of the dust.

The importance of having the solution properly clarified before precipitation is becoming more and more recognized, and the use of a clarifying press or other means of clarifying the solution before going to the precipitation apparatus is now judged essential for good work. By having a clear solution many of the difficulties of precipitation have disappeared.

H. A. Megraw[6] describes precipitation from cyanide solutions. He gives a summary of the history of precipitation and of the many different

[1] *Eng. Min. Jour.*, **97**, 845.
[2] *Eng. Min. Jour.*, **98**, 1007.
[3] *Bull. Amer. Inst. Min. Eng.*, Jan., 1914.
[4] *Bull. Amer. Inst. Min. Eng.*, July, 1914.
[5] *Bull. Amer. Inst. Min. Eng.*, Nov., 1914.
[6] *Eng. Min. Jour.*, **97**, 1232.

methods that have been used in the past. He shows the rate of precipitation of various metals and describes at length the action of interfering elements in the precipitation process.

P. S. Anderson[1] describes a simple and cheap tilting furnace for using the Taverner lead smelting process for refining zinc precipitates.

J. B. Tregloan describes[2] the use of a small tube mill for grinding short zinc shavings at the McNamara mill, Tonopah. By the use of this mill on the short zinc, acid treatment is dispensed with.

J. P. Caddy describes the method of precipitation and clean-up at the Lake View mill, Kalgoorlie.[3]

H. A. Megraw[4] describes the treatment of cyanide precipitates at different plants. The smelting and refining of precipitates he regards as one of the simplest processes in theory, but in practice it has been, until recently, the most imperfectly developed detail around a cyanide plant. Even at the present time a large number of mills melt their precipitates in the old-style coke-fired furnace, either direct or after acid treatment. However, the use of the oil-fired tilting furnace of the type of the Case, Monarch, or Steele-Harvey is coming into general use and makes the task of refining much more endurable than it has been in the past. As to the modern processes for refining, he gives in detail a description of the Homestake method, which uses a cupeling furnace for smelting the acid-treatment precipitate after being briquetted and a blast furnace for the cleaning of the litharge and slag from the cupel and for smelting other gold-bearing by-products, as designed and worked out by C. W. Merrill, and a description of direct smelting of the precipitates in a blast furnace as used at the Goldfield Consolidated mill by J. W. Hutchinson.

In the Merrill or Homestake system the precipitate, after being acid-treated, is partly dried, reducing its moisture content to about 17 per cent., the required flux added and the precipitate and flux briquetted under a pressure of 3500 lb. per sq. in. The briquettes, once made, are dried in a specially designed drying furnace at a low temperature. The scheme of treatment includes the direct cupelation of the briquettes, including the high-grade portion of the precipitate. The lower-grade material, which might make a pasty slag in the cupel, is treated in the blast furnace, together with other material. The cupel is made in a cast-iron frame and consists of a mixture containing 75 per cent. of Portland cement and 25 per cent. limestone, the latter sized between 10 and 30 mesh. In starting the cupeling operation, lead bullion from a previous run is melted in the test, and when a good heat is reached, the briquettes are charged through the working door into the bath. When the test is

[1] *Eng. Min. Jour.*, 98, 613.
[2] *Min. Sci. Press*, p. 287, Feb. 14, 1914.
[3] *Min. Sci. Press*. March 14, 1914.
[4] *Eng. Min. Jour.*, 97, 505, 506.

full, a slag car is run under the front and the fire clay wall is cut down, allowing slag and matte to flow out into the car. The front of the test is then built up again and the process repeated until all the precipitate is melted. More lead is then added, the last of the slag drawn off, and the air blast applied from the rear across the molten lead. Litharge is drawn off through channels cut in the front of the test. When the litharge is all gone, the heat is increased for a short time and the fire withdrawn. Just as the metal solidifies it is broken into pieces of appropriate size for re-melting in a crucible. The blast furnace used for melting down the low-grade precipitate and the by-products is an ordinary water-jacketed lead furnace with a round stack and three tuyères. It is operated with a lead well and forehearth, cast-iron cones serving for the latter. Each one is retained in service until matte is observed to overflow with the slag, then it is removed and another cone substituted. When cold, the cone is emptied, the button separated, matte reserved for shipment and the slag held for the next furnace run, when it is used over again. The slag which overflows the forehearth and runs into pots is rejected.

Direct blast-furnace smelting of precipitate is practised at the Goldfield Consolidated mill. The precipitate contains as much as 40 per cent. copper. The mixture consists of precipitates, 100 parts; litharge, 100 to 125 parts; blanket concentrates, 60 to 70 parts; and flue dust and floor sweepings, which reduces the moisture to 9 per cent. The mixture is then briquetted, dried, and sent to the blast furnace. The resulting lead bullion is cupeled and melted into bars. The bullion will average about 930 fine. At the Homestake plant, the costs of melting and refining are as follows:

Per lb. ppt.	$0.0889
Per oz. gold	0.0953
Per oz. gold and silver	0.0697
Per ton sol. precipitated	0.0085
Per ton treated	0.0046

At the Goldfield mill the costs were:

Labor	$0.023 per ton ore.
Supplies	0.032 per ton ore.
Power	0.000 (not estimable).

A. H. Jones[1] discusses refining conditions at the Belmont mill and gives the cost of melting, in a double Monarch-Rockwell furnace, of silver and gold bullion as follows:

REFINERY COST AT BELMONT MILL

Lining expense (Rockwell furnace)	$0.000238 per oz.
Flux	0.000693
Fuel oil	0.000524
Melting, briquetting, and general labor	0.000830
Power, blown, briquetting	0.000150
	$0.002435 per oz.

[1] *Eng. Min. Jour.*, 97, 967.

G. H. Clevenger[1] describes his experiments with a Faber du Faur furnace for the distillation of the zinc left in the precipitate in an endeavor to recover the zinc for further use.

U. S. Patent 1101569 was granted to Frank A. Ross for an apparatus for precipitating metals from solutions. The inventor proposes to precipitate, *e.g.*, gold-bearing cyanide solution, by causing it to flow successively through a number of revolving cylinders containing solid precipitant in the form of aluminium. Electrodes may be placed in each compartment, the idea being that electrolytic action will aid in the precipitation.

Charles Butters has patented[2] the use of aluminium in granulated or solid form. His process is carried out by passing the cyanide solution through a revolving tube mill containing a charge of aluminium in the form of small irregular bodies. The tumbling in the mill causes abrasion of the aluminium and prevents accumulation of gold and silver on the surface of the aluminium. The outflowing solution is sent to a filter press for the recovery of the suspended metals.

The use of granulated zinc in a tube mill, or other revolving drum through which cyanide solution is caused to flow, has been patented by Chas. H. Urquhart.[3] The inventor's apparatus is so arranged that the tube mill is at all times filled with solution so that no air is present. The outflowing solution, carrying the precipitated metals in suspension, is passed to a filter press to recover the gold and silver.

Chemistry of Cyaniding

Improvements in cyaniding have been principally mechanical during the last few years, but recently attention has been more or less directed toward the chemical side of the question and some noteworthy gains have been made and more can be expected. Interest in the desulphurizing process as introduced at the Nipissing mill has brought forth some careful discussion, the most illuminating and thoughtful of which is the paper by G. H. Clevenger[4] discussing Mr. Johnson's description of the Nipissing mill.[5] In the course of this discussion, Mr. Clevenger expresses his satisfaction that in the desulphurization process someone has brought forward a process depending upon reduction, as a foil to the innumerable oxidation methods now extant. He gives in detail his results and conclusions from many experiments by himself and others, and his paper makes a valuable summary of the chemistry of reduction as applied to

[1] *Eng. Min. Jour.*, **98**, 109.
[2] U. S. Pat. 1092765.
[3] U. S. Pat. 1090661.
[4] *Bull. Amer. Inst. Min. Eng.*, July, 1914.
[5] *Bull. Amer. Inst. Min. Eng.*, Jan, 1914.

cyanidation. Another very valuable contribution to the chemistry of cyanidation is made by Mr. Clevenger in his paper on the Function of Lead Salts in Cyanidation.[1] In this paper he first takes up the use of lead salts in their effect on precipitation. After giving a history of their use for this purpose he makes the following résumé:

1. The zinc-lead couple is of particular value in precipitating solutions containing copper or gold solutions low in cyanide.
2. In the majority of cases when the solution contains an appreciable amount of silver, the lead couple is unnecessary.
3. For forming the zinc-lead couple, it is necessary to use a soluble lead salt. Most generally the acetate has been used for this purpose, but the nitrate has been used at times on account of its higher lead content.
4. The zinc-lead couple necessitates the frequent removal of the inactive precipitant, which is a decided disadvantage, even when used for precipitating stronger solutions, for invariably some oxidation takes place in handling the decomposed zinc.

In the use of lead salts as an aid in extraction, he gives an account of the various experiences of operators and relates in detail the effect of lead salt upon the cyanidation of a certain Central American silver-gold ore. From various published results of the effects of lead salts in extraction and from the results of the detailed experiments upon the Central American ore, he draws the following conclusions:

1. Lead salts may serve to keep down the concentration of soluble sulphides in solutions, but they seldom function in this capacity for the reason that soluble sulphides are rarely present in mill solutions.
2. They may accelerate the dissolution of silver from ores in which the silver occurs as sulphide, through the more prompt removal of the sulphur ion from the system.
3. They may in certain cases with sulphide ores effect a saving of cyanide through retarding the formation of sulphocyanates or preventing the separation of elemental sulphur from the solution.
4. They may be a benefit when a portion of the silver is intimately associated with copper; also when the concentration of copper in the solution rises to a dangerous point, they might mitigate its fouling tendency.
5. A great variety of the compounds of lead may be used for this purpose. The acetate is most generally used, although litharge has been claimed to be equally satisfactory. The cost of the lead contents in litharge is perhaps lower than any of the others, but it is more difficult to apply, as it is necessary to grind it very fine and exercise care to see that it is thoroughly mixed with the charge undergoing treatment.
6. Too great care can not be exercised in adding the proper amount of lead salt. This can only be determined by careful experimentation in each particular case.
7. A number of those who have written upon the subject are of the opinion that lead salts may be of an advantage in starting a new plant with fresh solution, but that this advantage disappears after the solutions have been in use for some time. This clearly points to the fact that there are a number of substitutes which may perform

[1] *Min. Sci. Press*, **109**, 635.

the same functions that the lead salt would. Perhaps chief among these is zinc taken into solution during precipitation. Small amounts of mercury escaping from amalgamation processes preceding cyanide treatment would more or less function in the same way that lead salts do. Aeration might also at times be an efficient substitute.

8. On the whole, the advantages arising from the use of a lead salt are more apparent than in treating silver ores, or silver-gold ores in which the silver occurs in combination with sulphur, than in treating gold ores. In ores in which the silver is combined with antimony, it is likely to be a detriment. It may be said that the advantageous use of lead salts is one of the finer points of the game and, even in cases where its use might be advantageous, unskilled application may spoil the whole effect.

Herbert A. Megraw[1] discusses the chemicals used in the cyanide process. He describes at length the alkaline cyanides and the impurities found in them and the methods of adding cyanide to the working solutions in various plants. He treats most interestingly of the use of lime and of lead salts and their various modes of application. J. E. Clennell[2] describes the occurrence of molybdenum in cyanide solutions and gives a method for its detection. After making a number of tests with molybdenum compounds added to cyanide solutions, he comes to the conclusion that the effects of this element are not detrimental to the extraction. A. J. Weinig[3] also notes the presence of molybdenum in solutions and gives a method for its identification.

A chemical and historical review of the metallurgical processes which to-day hold first place as a means of recovering gold and silver from their ores is given by C. A. Mulholland.[4] The chemical reactions involved in the dissolution of metals and their compounds in cyanide solution is treated at length by the author. Chas. B. Brodigan gives a method for the colorimetric estimation of gold in cyanide solutions.[5] Solution control in cyanidation is discussed at length by A. W. Allen,[6] by J. S. Colbath[7] and by Harai R. Layng.[8]

The relative efficiency of sodium and potassium cyanide is considered in an article by Chas. Butters[9] and the article is discussed by C. M. Eye.[10] Victor Lenher gives some interesting studies on autoreduction in the precipitation of metallic gold.[11] Harai Layng calls attention to the importance of the action of sulpho-cyanides in cyanidation.[12] Some very interesting data regarding the distribution, and also loss, of cyanide at various points in a "milling-in-cyanide plant" are given by A. W. Allen in "Titration Results in Cyanidation."[13] This article is made additionally valuable by three diagrams showing graphic-

[1] *Eng. Min. Jour.*, **97**, 265.
[2] *Eng. Min. Jour.*, **97**, 363.
[3] *Eng. Min. Jour.*, **97**, 773.
[4] *Austral. Min. Stand.*, Jan. 8, 1914, pp. 15–22.
[5] *Met. Chem. Eng.*, **12**, 460.
[6] *Min. Sci. Press*, **108**, 14.
[7] *Min. Sci. Press*, **110**, 13.
[8] *Min. Sci. Press*, **109**, 606.
[9] *Min. Sci. Press*, **109**, 320.
[10] *Min. Sci. Press*, **109**, 480.
[11] *Min. Sci. Press*, **109**, 411.
[12] *Min. Sci. Press*, **109**, 481.
[13] *Min. Sci. Press*, **109**, 247.

lly the amount of free cyanide, double cyanide and protective alkalinity t various points in the mill circuit.

Milling Practice

United States.—Robt. A. Kinzie[1] describes the Pilot mill now being sed by the Alaska Juneau Gold Mining Co. Lewis H. Eddy[2] describes he Argonaut mill and tailings plant, in Amador County, Cal. The Buckhorn mill[3] at Buckhorn, Nev., commenced operations in February, 1914. The plant consists of a 20 by 10-in. Blake crusher fed by a haking screen from a 30 by 20-ft. steel ore bin; a 32-in. by 10-ft. washing creen; 40 by 15-in. Gates Anaconda-type rolls; 6-ft. by 16-in. Hardinge onical mill; two 12-in. bucket elevators; two 45-in. by 15-ft. Akins lassifiers, and two 5 by 18-ft. Allis-Chalmers chain-driven tube mills with Komata liners. The cyanide plant consists of three 32 by 15-ft. Dorr gitators connected for continuous agitation, followed by six 35½ by 12-. Dorr thickeners, and arranged for a change of solution between the rst and second set of three thickeners. Decanted solutions are clarified 1 three 35 by 60-in. Perrin presses and precipitated with zinc dust, using wo 52 by 30-in. Merrill precipitating presses. The thickened slime is ltered in four 14-ft. diam. Oliver filters. It was found after starting hat, owing to the extremely colloidal nature of the Buckhorn ore, additional filter area was required and also more settling area. Two more Oliver filters were added and one of the Dorr agitators was operated lowly as a Dorr thickener. Geo. T. Castleton[4] describes the mill of the Griggs, Castleton & Carter Co. treating oxidized lead-silver tailings ontaining a little gold at Eureka, Utah. Lyon Smith[5] describes the peration of the Pittsburgh-Silver Peak mill at Blair, Nev. He gives flow heet and costs.

The mill of the Presidio Mining Co. at Shafter, Texas,[6] has been hanged from a pan amalgamation mill to the cyanide process. The ore s a siliceous limestone, carrying silver as the chloride and bromide embolite). It averages about 18 oz. per ton. An analysis shows: SiO_2, 61.8 per cent.; CaO, 11.8; Fe, 4.5; Mg, 2.4; Zn, 2.4; Mn, 0.4; Pb, 0.5; S, 0.2; CO_2, 13.2; undetermined, 2.8 per cent. In part it is soft and talcy, and in part extremely hard. The mill is now treating between 130 and 140 tons per day. Ore from the mine is crushed and transported to the mill ore-bin by an aerial tramway. Challenge feeders supply ore to three batteries of five stamps each which crush 8.4 tons per stamp through 10-mesh screen. From the batteries the pulp goes to two screw classi-

[1] *Eng. Min. Jour.*, **97**, 314.
[2] *Eng. Min. Jour.*, **97**, 380.
[3] *Eng. Min. Jour.*, **97**, 484.
[4] *Eng. Min. Jour.*, **98**, 863.
[5] *Eng. Min. Jour.*, **98**, 596.
[6] *Min. Sci. Press*, Oct. 24, 1914, p. 643.

fiers working in closed circuit with two 4½ by 18-ft. tube mills. Bucket elevators take the discharge from the classifiers to a 5-ft. diaphragm cone classifier and then to a 30 by 10-ft. Dorr thickener. Thickened slimes go to four 14 by 28-ft. Pachuca agitators working in series. From the agitators the pulp goes to a 30 by 10-ft. Dorr thickener and the thickened pulp to an 11½ by 14-ft. Oliver filter. Solutions are clarified in two 4 by 16-ft. tanks, and the clear solution to zinc boxes. Precipitates average 30 per cent. in silver and are melted in a Donaldson tilting furnace. Power is supplied by two De la Vergne crude-oil engines.

Wallace MacGregor[1] describes the mill of the Globe Consolidated Mining Co. at Dedrick, Trinity County, Cal. The mill is a 20-stamp, all-sliming cyanide plant with a capacity of 100 tons per day. The plant is operated by water power, there being a separate water wheel in each department. Ore is stamped in solution and goes to a Dorr classifier and tube mill in closed circuit. Classifier overflow is agitated in Dorr agitators and then goes to Dorr thickeners using counter-current decantation. The thickened pulp is filtered in an Oliver filter. Precipitation is by means of zinc shavings. H. A. Morrison[2] also describes this mill, and H. A. Morrison[3] and H. G. Thompson describe the operation of the Oliver filter in the Globe mill.

E. H. Leslie[4] describes the new mill of the Commonwealth Mining & Milling Co. of Pearce, Ariz. The ore from the mine is trammed in 2-ton cars to the receiving bin in the preliminary crushing house. This bin is 24 ft. in diam. and 29 ft. high and built of ¼-in. steel plate. Ore from the bin is drawn through a 3 by 5-ft. "finger" gate to a No. 6, style "K" Gates gyratory crusher. The crusher discharges into a Gates revolving screen, 40 in. by 12 ft. with 1½-in. holes. The undersize passes directly to a belt conveyor which elevates it to the battery bins. The oversize goes to two No. 4, sytle "K" Gates crushers set at 1½-in. discharge, which deliver the crushed ore to the conveyor. The conveyor operates on a 20° incline. The conveyor discharges into a hopper at the bottom of which is a No. 2 Vezin sampler. The reject goes to a cross-conveyor 95 ft. long and 18 in. wide, which delivers the ore to the battery bins by means of a self-propelling and reversing tripper. The battery bin is of standard type, 16 by 16 by 60 ft., with a storage capacity of 800 tons. The ore is discharged at the bottom through six gates, 24 in. by 4 ft. 4 in., to six Challenge feeders, passes over six 2 by 3-ft. shaking screens with 3/16-in. perforations. The undersize is washed by solution through an 8-in. pipe and joins the battery discharge at the front of the mortar box. The oversize is fed with solution into the mortars of three 10-stamp

[1] *Min. Sci. Press*, Feb. 14, 1914, p. 290.
[2] *Eng. Min. Jour.*, 98, 423.
[3] *Min. Sci. Press*, Oct. 10, 1914, p. 554.
[4] *Min. Sci. Press*, May 2, 1914, p. 722.

batteries, the weight of the stamps being 1550 lb., each of which drops 7 in. and makes 100 drops per min. The battery foundations are of concrete and adopted from the South African practice. The batteries are equipped with 2-mesh screens. The battery discharge, together with the by-passed material, flows to three 5-ft. Caldecott cones. The underflow from the cones supplies feed to three 8-ft. by 30-in. Hardinge mills, while the overflow is by-passed and joins the discharge from the Hardinge mills and goes thence to three Dorr classifiers. The Hardinge mills are driven by individual 50-h.p. motors and make 28 r.p.m. Nine hundred pounds of Danish pebbles are used in the three Hardinge mills per day and an equal amount in the tube mills. The discharge from the Hardinge mills unites with the overflow from the cones and is redistributed to three duplex Dorr classifiers which discharge to three tube mills operating in closed circuit. The overflow from the classifiers goes to the first set of two Dorr thickeners, 38 ft. in diam. by 12 ft. high. Lime is added in the feed launders of the Dorr thickeners at the rate of about 13 lb. per ton of ore. The NaCN consumption is about ¾ lb. per ton of ore treated. The overflow from the Dorr thickeners is conducted to a 20 by 10-ft. mill solution return sump, while the thickened discharge is elevated by two air-lifts to the Pachuca tanks. It is proposed to replace these air-lifts by diaphragm pumps. There are nine Pachuca tanks and continuous agitation is maintained in eight tanks, the other being kept as a reserve. The discharge from the last Pachuca is conducted to the first of two sets of two Dorr thickeners, each 42 ft. in diam. by 12 ft. in height. The overflow from the first two Dorr thickeners is conducted to a 20 by 12-ft. rich solution tank. The feed to the first thickeners is 2½ parts solution to 1 of solids and the discharge contains ½ moisture to 1 of solids. The discharge from the first thickener is elevated to the second thickener and is diluted to 2½ to 1, which in turn is thickened in a second set of two thickeners. The overflow from the second thickeners is returned to the mill system. The discharge from the last thickeners goes to four Oliver filters, 11 ft. 5 in. long by 18 ft. diam. The solution from the rich solution sump is pumped to two Merrill clarifying presses and then to two 52-in. Merrill precipitating presses having 38 frames each. The precipitate, when dry, is fluxed and smelted in two Donaldson tilting furnaces. Since this article was published, the agitating capacity of the plant has been increased by operating one Dorr thickener as a Dorr agitator by speeding it up and elevating the discharge through an air-lift outside the tank and returning it to a distributing launder in the center of the tank.

The new mill of the Aurora Consolidated Mines Co., at Aurora, is

described by "an occasional contributor."[1] This article was evidently written before the mill began operation and before defects in the design of this plant had been discovered. These defects in design were due chiefly to the fact that the ore treated varied from the ore supplied for preliminary tests. The mill, as originally built, was designed to handle 500 tons per day as an all-slimed product. The ore is chiefly gold, with a small amount of silver, averaging close to $5 per ton, and disseminated quite evenly through a hard quartz. It is trammed from the mine by electric haulage and dumped into two steel storage bins in the preliminary crushing house. From the bins it passes to a No. 2½ Gates crusher, to a trommel screen with 1½-in. openings, the oversize going to two No. 4 Gates crushers set at 1½ in., joining the undersize from the screen; it passes to a belt conveyor which elevates it to four steel battery bins having a capacity of 1600 tons. It is fed by suspended Challenge feeders to forty 1660-lb. stamps, dropping 100 times per min. through a drop of 7 in. The screens on the battery are 3 mesh. Solution is added in the stamps and the pulp is carried by launders to six duplex Dorr classifiers working in closed circuit with six 6 by 16-ft. tube mills. The overflow from the classifiers goes to three 30-ft. Dorr thickeners, each thickener taking the product from two tube mills. The thickened pulp goes to five Dorr agitators arranged for continuous operation. From the last agitator the pulp passes to the Trent replacing tanks of which there are four. From the replacers the pulp goes to three Trent filters. The solution is clarified in two Merrill clarifying presses and goes to two 52-in. Merrill precipitation presses. Later reports tell of the abandonment of the Trent replacing system and the Trent filter and the installation of Merrill slime presses in place of them. Additional settling capacity has been obtained by adding Dorr tray thickeners and changing the thickeners there to tray thickeners.

Jesse Simmons[2] describes the new mill of the Mogul Mining Co., near Trojan, S. D. This plant uses continuous decantation without filters. The mill is so situated that bottom-dump railroad cars discharge into the crusher bin. After passing through a No. 5-D Gates crusher, the ore goes by shaking feeder to a 14 by 36-in. roll, delivering a product of about 1-in. cubes. Thence it is delivered by an 18-in. S-A conveyor, set at an incline of 22°, to two cylindrical steel bins, 16 by 14 ft., from either of which it is possible to feed either one of two 6-ft. Trent Chilean mills. As this conveyor discharges into bins a sample is automatically taken by cutting across the stream of pulp every 35 sec., making it practicable to get a close sample on a small lot of ore. Cyanide solution is added at

[1] *Min. Sci. Press*, July 11, 1914, p. 57.
[2] *Min. Sci. Press*, July 23, p. 1059.

the Chilean mill and the product elevated in a 16-in. bucket elevator to a Dorr duplex classifier, the overflow from which goes to a 35 by 10-ft. Dorr thickener; the underflow goes to a 5 by 18-ft. tube mill which is operated in a closed circuit with the classifier. The result is that a product is treated of which about 1 per cent. is coarser than 60 mesh and 40 to 50 per cent. finer than 200 mesh. From the 35-ft. thickener the clear overflow is transferred to the zinc boxes, first passing through a clarifying filter, and the underflow of thickened slime runs by gravity to three 15 ft. 6 in. by 16-in. Dorr agitators in series, taking about 8 to 10 cu. ft. of free air per min.; thence by gravity to the continuous decantation installation of four Dorr thickeners in 25 by 10-ft. tanks. At No. 3 thickener, barren solution is added and at No. 4, the last in the series, wash water is used. Between the thickeners the pulp is handled with diaphragm pumps. At this plant the moisture contents of the slime drawn from the thickeners averages 40 per cent. The only solution precipitated is that drawn off the 35-ft. thickener, about 2¼ tons per ton of ore. The capacity of the plant is 150 tons per day. Dissolved values run from 4 to 7 cts. per ton, depending upon the gold content of the barren solution which usually runs about 2½ cts. per ton. The total cyanide consumption is about 0.5 lb. per ton.

The New Reliance mill in South Dakota has already been described in MINERAL INDUSTRY, **21**, 331, but an article by Jesse Simmons gives a later account of its operation. This plant uses counter-current decantation followed by a Portland filter. Dissolved gold losses run from 2 to 5 cts. per ton of dry slime. Cyanide consumption is 0.3 lb. per ton and lime, 10.75 lb. per ton.

The design of the new 100-ton cyanide mill for the Rochester Mines Co. at Rochester, Nev., construction of which is now under way, presents some interesting features, particularly with reference to continuous counter-current decantation.[1] Metallurgical treatment will begin by crushing in solution with ten 1550-lb. stamps. The stamp discharge will be classified into sand and slime in a Dorr classifier specially designed to give extra settling area, being deeper and longer than the standard machine. The grinding will be completed in two 5 by 16-ft. tube mills connected by clutches to a single 100-h.p. motor equipped with silent chain drive. For the recovery of the pregnant solution there is one 28 by 12-ft. Dorr thickener, followed successively by three 28 by 16-ft. Dorr agitators and five 28 by 10-ft. Dorr thickeners. The agitators will be operated in series. The last five thickeners have successively 2 ft. greater elevation to provide for return of decanted solution by gravity. Diaphragm pumps will be used to elevate the thickened pulp

[1] *Met. Chem. Eng.*, **12**, 677.

through the series. The mill is intended to treat ore carrying much silv which may require stronger cyanide solutions, and the extra thickener added to reduce the mechanical loss in cyanide.

Paul W. Gaberlein[1] describes the mill of the Cornucopia Mines C in Baker County, Oregon. The ore is hard quartz containing from 3

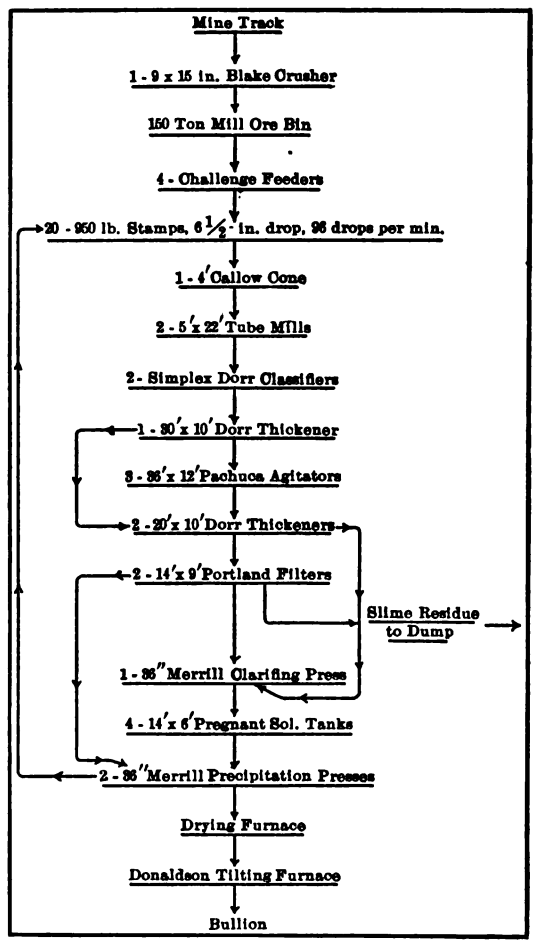

Mine Track
1 - 9 x 15 in. Blake Crusher
150 Ton Mill Ore Bin
4 - Challenge Feeders
20 - 950 lb. Stamps, 6½ in. drop, 96 drops per min.
1 - 4′ Callow Cone
2 - 5′ x 22′ Tube Mills
2 - Simplex Dorr Classifiers
1 - 30′ x 10′ Dorr Thickener
3 - 36′ x 12′ Pachuca Agitators
2 - 20′ x 10′ Dorr Thickeners
2 - 14′ x 9′ Portland Filters
Slime Residue to Dump
1 - 36″ Merrill Clarifing Press
4 - 14′ x 6′ Pregnant Sol. Tanks
2 - 36″ Merrill Precipitation Presses
Drying Furnace
Donaldson Tilting Furnace
Bullion

FIG. 1.—Flow sheet of the Cornucopia mill.

5 per cent. pyrite, which carries the gold. Silver is present in the pr portion of 1 to 5 of gold. The ore ranges from $10 to $20 in value. Th mill has a capacity of 150 tons per day. The ore is reduced to 1½-i size in a 9 by 15-in. Blake crusher and passes to a 150-ton bin, from whic

[1] *Eng. Min. Jour.*, 97, 455.

it is fed by Challenge feeders to twenty 950-lb. stamps dropping 98 times per min. through 7 in. Screens are No. 930 ton-cap, corresponding to about 8 mesh. Six tons of 0.125 per cent. solution are added at the stamps. Stamp duty is 7.15 tons per stamp. Pulp passes to two 4-ft. Callow cones, the sands going to two 5 by 22-ft. tube mills, the overflow to two simplex Dorr classifiers. The mills discharge into the Dorr classifiers, working in closed circuit. The classifier discharge, which contains 86 per cent. finer than 200 mesh, goes to a 30 by 10-ft. Dorr thickener where it is thickened to 2 : 1 for agitation. Thickener overflow is used for dilution after agitation in the counter-current thickeners. Agitators are three 12 by 36-ft. Pachuca tanks worked in series. About 35 per cent. of dissolution takes place in the mill and 65 per cent. in the agitators. The pulp from the agitators, after dilution with the solution from the first thickener, is treated by counter-current decantation in two 20 by 10-ft. Dorr thickeners. The underflow from the last thickener is filtered by two 14 by 9-ft. drum filters. The solution precipitated comes from the first 20-ft. Dorr thickener and from the filters. It is clarified in a 36-in., 18-frame Merrill clarifying press and is precipitated with zinc dust in two 36-in., 18-frame Merrill presses. The extraction is 90 per cent. of the gold and from 70 to 80 per cent. of the silver. Cyanide consumption, 1.4 lb.; lime, 3 lb.; zinc dust, 0.9 lb. per ton of ore.

E. C. Morse[1] describes mining and milling at Republic, Wash. He describes the San Poil mill which was noted in MINERAL INDUSTRY, **21.**

S. P. Warren[2] describes the mill of the Hilltop Milling and Reduction Co. at Hilltop, Nev. The mill is equipped with a 7 by 10-in. Blake crusher; ten 1150-lb. stamps dropping 105 times per min.; one Dorr duplex classifier working in closed circuit with a 4 by 20-ft. tube mill; one primary 20 by 10-ft. Dorr thickener; three 10 by 25-ft. Pachuca agitators; one secondary 20 by 10-ft. Dorr thickener; one 10 by 12-ft. Oliver filter; six series of nine each, round, separate compartment zinc boxes. Power is furnished by two single-cylinder oil engines, one 32 hp. and one 60 hp. Costs are $2.53 per ton. Arrangement of the mill is shown on flow sheet, Fig. 2.

A. H. Roller and H. T. Curran[3] describe the ore treatment at the Argo mill, Idaho Springs, Colo. A later and more accurate description of this mill is given by Jackson A. Pearce in an article on Cyanidation of Clear Creek and Gilpin County Sulphides.[4] The ore carries galena, chalcopyrite, chalcocite, sphalerite, argentite and other silver minerals, and gold. Sylvanite seems widely distributed though not in abundance. Pyrite and marcasite predominate. This mill was described in a previous volume

[1] *Min. Sci. Press*, **109**, 435.
[2] *Colo. School of Mines Mag.*, **4**, 51.
[3] *Eng. Min. Jour.*, **98**, 1.
[4] *Min. Sci. Press*, **109**, 833.

of MINERAL INDUSTRY. A flow sheet of the mill, shown in Fig. 3, gives plainly the changes that have been made since the former article was published.

A combined stamp mill and cyanide plant was built during the year by the Sunset Mining & Development Co. at Rhyolite, Nev.[1] This mill treats 2000 tons per month. It is equipped with Blake crusher, ten 1050-

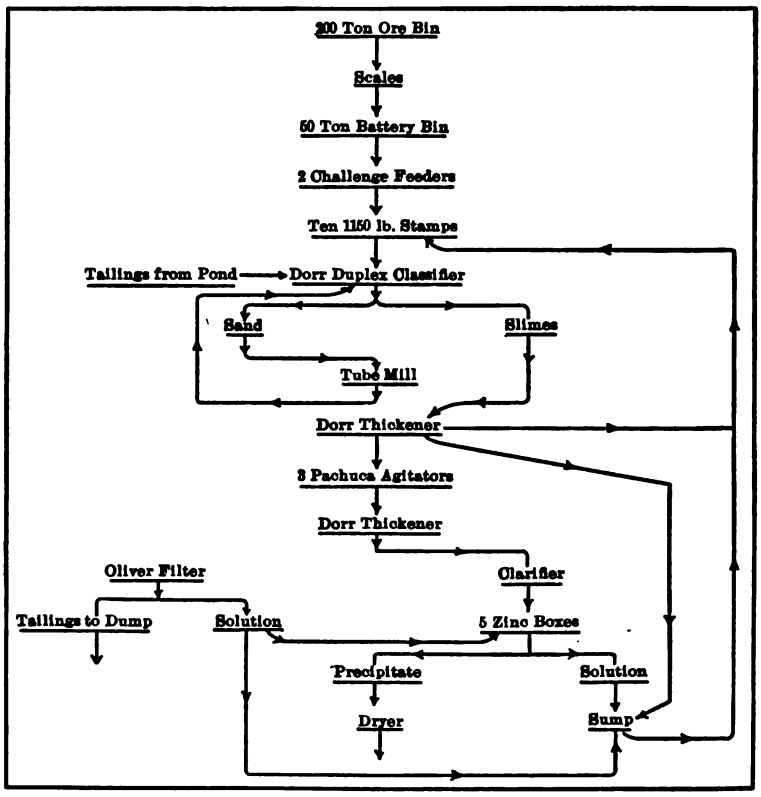


FIG. 2.—Flow sheet of the Hill Top mill.

lb. stamps, Akin classifier, tube mill, amalgamation plates, Dorr thickeners, Pachuca agitators, and a Portland filter.

Frederick Bradshaw,[2] in an article on Tonopah in 1914, says: "The Tonopah Mining Co. of Nevada new 500-ton cyanide mill at Millers, Nev., originally a plant in which about half of the tonnage was leached as sand and the other half was slimed, agitated and filtered, has been remodeled and, by the addition of tube mills, made into a 400-ton all-sliming mill. The counter-current system of continuous decantation is

[1] *Min. Eng. World*, 42, 21. [2] *Eng. Min. Jour.*, 99, 154.

d and better extractions have been attained. The company owns ıtrol of the Tonopah Placers Co., which is successfully operating gold

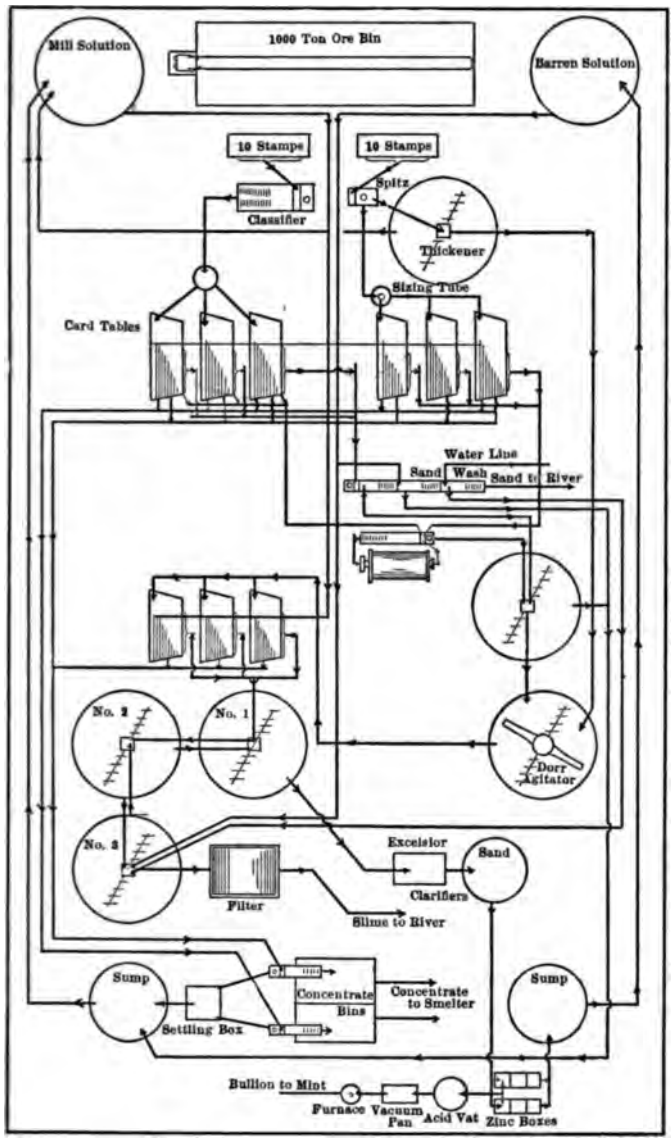


FIG. 3.—Flow sheet of the Argo mill.

dges at Breckenridge, Colo. The company is also developing promis- gold properties in Nicaragua.

"The Tonopah Extension Mining Co. during 1914 increased its 30-stamp mill by the addition of 10 stamps, two tube mills and eight concentrating tables, and is at present milling 250 tons daily. At the new shaft a new Nordberg hoist and a 1500-cu. ft. motor-driven direct connected air compressor and many other improvements were installed.

"The West End Consolidated Mining Co. completed the enlargement of its mill, adding 10 stamps and a tube mill."

J. T. Terry[1] describes the method of cyaniding tailings in the Willow Creek district, Alaska. The ore from the mine is crushed in a five- and a two-stamp battery to 50 mesh, the pulp, going over plates to a Wilfley table, thence to tailings ponds, from which it is recovered and subsequently cyanided. The cyanide tank consists of six leaching tanks, sump, storage, and solution tanks, and has a daily capacity of 45 tons of tailings. An extraction of 86.6 per cent. of the gold was obtained on sands running $13.50 per ton.

Canada.—James Johnson[2] describes the mill and metallurgical practice of the Nipissing Mining Co., Ltd., at Cobalt, Ont. At this mill a remarkably complex silver ore, averaging 54 oz. of silver per ton, is treated to give a 95.66 per cent. extraction. Mr. Johnson points out that the main features of the process are: The cyanide treatment of the high-grade ore; the cyanide treatment of the low-grade ore, after extremely fine grinding and close classification in Dorr classifiers in a caustic soda solution; the use of a wet desulphurizing process to break up refractory silver minerals; the substitution of aluminium dust for zinc dust as a precipitant. The present mill practice is summed up as follows: Crushing to 3 in. in gyratory crushers before sending to washing plant; hand picking and jigging of the high-grade ore in the washing plant, which is then sent to the high-grade-ore mill; discard from washing plant, known as low-grade ore, crushed to 1.5 in. and sent to the battery; crushing in battery and tube mills in a caustic soda solution to all slimes; collecting slimes and desulphurizing in tube mills and vat; dewatering slimes and transferring to vats for cyanide treatment; filtering slimes and discharging to waste dump, cyanide solution from slimes treatment vats and filters going to aluminium dust precipitation; aluminium dust precipitate taken to refinery, matted and refined to silver bullion at 997 to 999 fine. The desulphurizing process is the important novel feature of the process. The desulphurizing is accomplished by passing the slime pulp through a revolving tube mill in which there is a quantity of aluminium ingots, cut up into cubes about 2 in. in size. A further treatment is given in a vat lined with aluminium plates. A better extraction of from 1 to 4 oz. per ton is obtained when desulphurized and cyanided, as com-

[1] *Min. Sci. Press*, 109, 989.

[2] *Bull. Amer. Inst. Min. Eng.*, Jan., 1914.

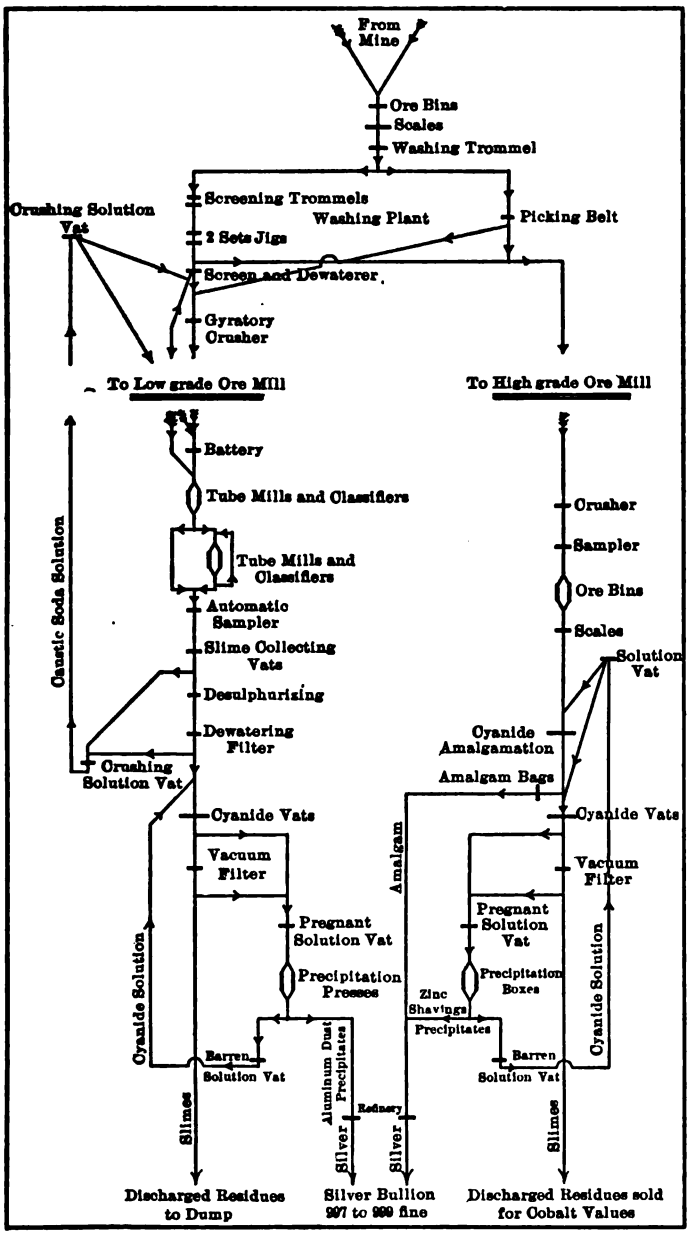


FIG. 4.—Flow sheet of Nipissing Mining Company's mill.

pared with straight cyanide treatment. After the desulphurizing treatment the pulp is dewatered to eliminate as much as possible the caustic soda solution. This is done in a Butters filter plant equipped with 60 leaves, which is capable of dewatering 270 tons of slimes per day, the cake carrying 26 per cent. alkali solution as moisture. After dewatering, the slimes pass to a 16 by 5-ft. pulping vat where they first come in contact with cyanide solution, being diluted with about 2 of cyanide solution to 1 of slime, the strength of the solution being 0.25 per cent. KCN. It is then transferred to a 4-in. centrifugal pump to the treatment vats, of which there are seven, each 34 by 13 ft., fitted with mechanical stirring arrangement. The slimes are treated in charges of 130 tons dry slimes, the dilution being 2 to 1. After agitation the charge is allowed to settle and the clear solution decanted to the pregnant solution vat. The pulp is then agitated and transferred by a centrifugal pump to the stock vat, in which it is kept agitated until drawn off into the filter box. A Butters filter plant equipped with 80 leaves handles 35- to 40-ton charges in about 3 hr. each, the slimes being discharged with 26 per cent. moisture. The pregnant solution is precipitated with aluminium dust as described in MINERAL INDUSTRY, 21. The benefits of using aluminium as a precipitant on these solutions are: no fouling of cyanide solutions, with a corresponding reduction in dissolving efficiency; the working mill solutions have a greater dissolving efficiency than fresh solutions, dissolving 0.35 oz. of silver more per ton of ore; a regeneration of 0.608 lb. of cyanide per ton of solution treated; the silver precipitates average about 93 per cent. silver. The aluminium dust consumption averages about 0.556 lb. per ton of ore treated, or 1 lb. equals 45.26 oz. silver precipitated. The precipitates are melted in a reverberatory furnace. This article is discussed at length by G. H. Clevenger.[1]

Continuous decantation at the Porcupine Crown mill is described by Maurice Summerhayes.[2] The ore treated is a hard quartz containing approximately 1 per cent. of iron pyrite. The grade varies from $18 to $30 per ton. Some of the gold is coarse, but generally it is fine and freely disseminated in the quartz gangue, often associated with the pyrite. With the ore proper, from 10 to 20 per cent. of country rock is sent to the mill. The ore is dumped upon a grizzly spaced 1½ in. The oversize goes to a No. 3 Chalmers & Williams gyratory crusher set at 1½ in. The crusher discharge joins the undersize from the grizzly and is taken by a belt elevator to a 265-ton battery bin, from which it is fed by Challenge feeders to twenty 1050-lb. stamps, dropping 102 times per min. through 7½ in. Screens are 2½ mesh and 6 mesh, which are varied to suit mill requirements. The stamps discharge to two Dorr

[1] *Bull. Amer. Inst. Min. Eng.*, July, 1914. [2] *Min. Sci. Press*, July 18, 1914.

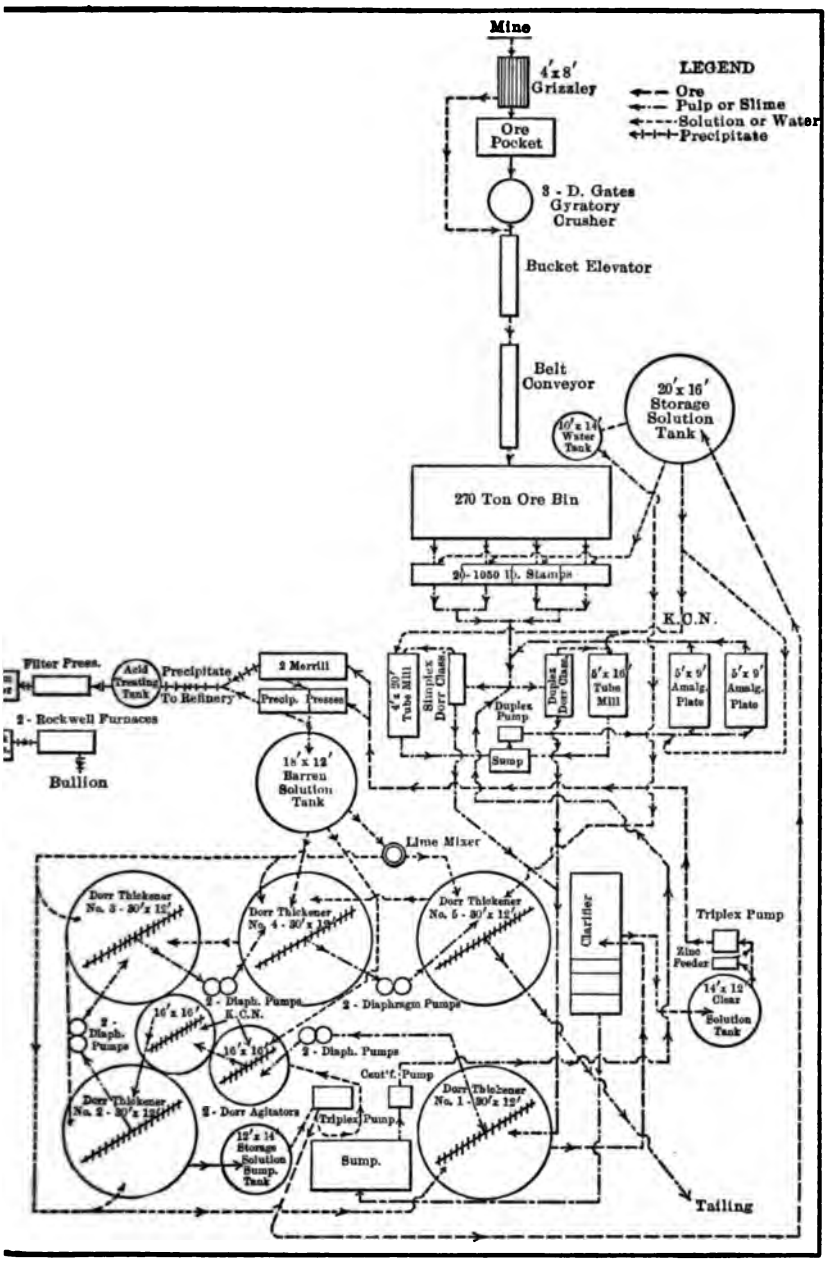


FIG. 5.—Flow sheet of Porcupine Crown mill.

classifiers, a duplex in closed circuit with a 5 by 16-ft. tube mill and a simplex in circuit with a 4 by 20-ft. tube mill. The discharge from the tube mills is elevated by a plunger pump to two 5 by 9-ft. amalgamating plates where about 30 per cent. of the gold is recovered. The tube mills, classifiers, and amalgamating plates are thus in a closed circuit. The combined slimes from the classifiers goes to a 30 by 12-ft. Dorr thickener. The overflow from this tank is pregnant solution and goes to precipitation. The thickened pulp (35 per cent. moisture) is taken by a diaphragm pump to a 16 by 16-ft. Dorr agitator. Here the moisture is raised by adding barren solution until the same has reached 60 per cent. One-third of the cyanide is added at this point, the balance at the tube mill

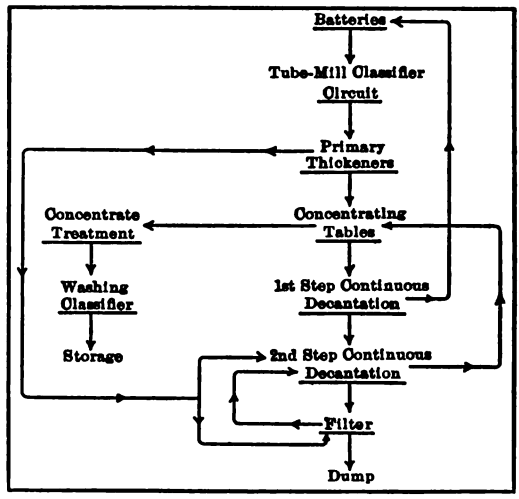


FIG. 6.—Flow sheet of present treatment at the Hollinger mill.

feed. The pulp from the agitator is discharged continuously to No. 2 thickener. Then from this point to thickeners 3, 4 and 5 the decantation is continuous, each tank having a 2-ft. elevation above the next preceding one, giving the overflow a gravity flow. The underflow from each thickener is handled by diaphragm pumps. The underflow contains from 30 to 40 per cent. moisture. Zinc dust in Merrill presses is used for precipitation. The grade of the precipitate obtained is $27.50 per lb. from pregnant solution averaging $2.83 per ton. Since this article was written another Dorr agitator has been added and the dissolution in thickeners reduced. The dissolved losses are reported to average 4 cts. per ton.

Details of the changes made at the mill of the Hollinger Gold Mines, Ltd., at Porcupine are described by H. C. Parmelee[1] and H. A. Megraw.[2]

[1] *Met. Chem. Eng.*, 12, 567.

[2] *Eng. Min. Jour.*, 97, 385.

stamps have been added and the flow sheet has been altered to de partial counter-current decantation. The first step is per- ed in four 30 by 15-ft. Dorr thickeners. The pulp issuing from is taken to another set of four 30 by 12-ft. Dorr thickeners. It is ed with treatment solution before entering these thickeners, whereby dditional dissolution of gold, with its consequent recovery, is ob- d. From the second set of thickeners the pulp is raised by diaphragm ps and sent to the filtering system. The filter is the same Moore plant which was installed in the original plant and which is now ated in the same way as formerly. The two flow sheets, Fig. 6,

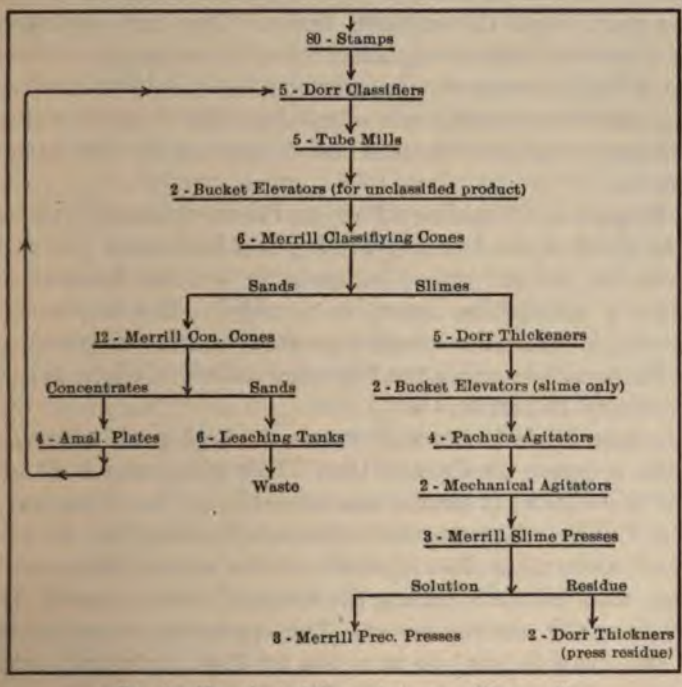


FIG. 7.—Flow sheet of the newly-arranged Dome mill.

plainly the changes that have been made. Since this description published the company has enlarged their mill and built a separate under the same roof to treat Acme ores. This will be by continuous ter-current decantation alone, while the old mill, much enlarged, will a separation of colloids, treat that portion of the ore by filtering and balance by continuous counter-current decantation.

Enlargement and re-arrangement of the Dome mill, South Porcupine, has been completed.[1] An additional quota of 40 stamps, 1250 lb.

[1] *Eng. Min. Jour.*, **98**, 527.

each, has been placed at the rear of the mill bin so that the stamps now stand back to back. The ore bin has been raised 6 ft. to accommodate a greater tonnage. Crushing is still to be performed in water, but there are no primary amalgamating plates. Plate amalgamation is performed after re-grinding in the tube mills. Pulp is separated in Merrill classifying cones and the slimes treated identically as before. The amalgamating plates have been removed from the lower part of the mill and placed in the upper part of the new addition where they are served with pulp from the elevators. Sands are passed through concentrating cones, the concentrates re-ground and the sands sent to the leaching tanks. Precipitate presses have been removed from the lower part of the mill and are now in the upper part, over the solution tanks. This new arrangement is expected to greatly increase capacity, which is necessary in view of the low grade of the ore reserves. Re-grinding cost should be much reduced, as will also treatment costs, since simple leaching of sands is cheap, and slimes treatment will be reduced in cost because of the elimination of all sands from it.

H. A. Megraw in Cyaniding a Furnace Product[1] describes the methods used at the plant of the Del Oro Mining and Reduction Co. at Deloro, Ont., where the ore is reduced to speiss in a blast furnace and the speiss, after a chloridizing roast, is cyanided. The treatment is remarkably simple for such a complex product, and the extraction is high.

H. C. Parmelee[2] describes the Nipissing mills at Cobalt, and the mill of the Dominion Reduction Co.

The Buffalo High Grade mill[3] treats the high-grade silver ore from the Buffalo property at Cobalt, Ont. This plant was built after the success of the somewhat similar one operated by the Nipissing Mining Co., also of Cobalt. The essential difference between the two is that the Buffalo mill undertakes the treatment of the concentrate made at the main plant, while at the Nipissing the material treated is solely the high-grade ore from the various mines. The concentrates are treated with mercury and cyanide solution in a 5½ by 22-ft. tube mill, making 27 r.p.m., essentially as is done at the Nipissing plant.[4] After recovering the amalgam, the tailings from this process are taken to one of three Dorr agitators, operated on the charge system, where the recovery of the remaining silver is effected with strong cyanide solution. The treatment is not widely different from that followed at the Nipissing high-grade mill, although the apparatus is of different make and arranged differently. A departure at the Buffalo mill is the additional treatment given to the cyanide residues to recover the mercury from them. The residues are

[1] *Eng. Min. Jour.*, 98, 147.
[2] *Met. Chem. Eng.*, 12, 507.
[3] *Eng. Min. Jour.*, 98, 485.
[4] *Eng. Min. Jour.*, Nov. 7, 1912.

ered through a Moore filter in the usual way, washed and then, without opping the cake, the basket of leaves is passed to an additional tank, d a solution drawn through it which takes the mercury into solution. is is later precipitated and the mercury recovered. Precipitation is ected with aluminium dust and the precipitate is retorted to recover e mercury it carries.

Japan.—Taro M. Yoshida[1] describes the milling practice at the amagano Gold Mines, Satsuma, Japan. This mine was discovered the early part of the 13th century and is credited with a production of ore than $24,000,000. In 1907 a new mill with an annexed cyanide ant was built. There are two stamp mills, one at Yamagano and one Nagano. In the former there are 20 stamps of 900 lb. weight, the mill ushing 660 long tons of ore monthly. The pulp flows over four sets fixed and shaking amalgamating plates and into spitzkasten, in which is separated into sand and slime. The slime is sent directly to the aniding plant at Ipponsugi, while the sand is concentrated and re-assified on three Wilfley tables. The heavy amalgam and pyrites are ubjected to pan amalgamation, while the light sand and slimes are sent Ipponsugi. The cyanide plant of Ipponsugi is about three-quarters a mile distant from the Yamagano mill. In this plant sand and slime, ith 1 per cent. of lime added, are leached in wooden tanks 20 ft. in am. and 4½ ft. deep. The principal installation is the Nagano etallurgical works, which includes stamp mill and sand and slime plants. he ore is discharged from tram cars upon a grizzly 6 ft. 8 in. wide and 5 ft. long by a hand tipple, the coarse rock going to a gyratory crusher, ing reduced to a 2-in. size. From the crusher the ore is trammed to 50-ton battery bins, fed by suspended Challenge feeders to 80 stamps, eight 900 lb., dropping 80 times per min. through 8 in. They crush 200 long tons of ore per month, through a 30-mesh screen. The pulp uns over 16 pairs of fixed and shaking amalgamating plates and flows nto four hydraulic cone separators, from which the slime overflow runs irectly to the slime-cyaniding plant, while the sands are run over 11 Wilfley tables where the heavy amalgam and pyrites are caught and the ailings are led to the sand tanks through a launder. The concentrates re sent to the smelter at the Ikuno mine. The amalgam contains 19 per ent. gold and 13 per cent. silver. The sand plant contains four collect-g tanks 30 ft. by 6 ft. 4 in. with a total capacity of 110 long tons. Each nk is equipped with a Butters distributor and slat gates for discharging e slime overflow. After the tank is filled with sand and the water is awn off, the sand is shoveled out and trammed to six 30-ft. by 7-ft. in. leaching tanks. Here 0.5 per cent. of lime is added and the sand

[1] *Eng. Min. Jour.*, **97**, 161, 217.

leached with a 0.3 per cent. KCN solution. The slime is run to two iron cones, allowed to settle, and the clear water drawn off. The settled slimes, which still contain 1.5 parts of water, are drawn in agitating tanks, KCN added, and the pulp agitated for 10 hr., when it is sent to Dehne filter presses. Zinc shavings are used for precipitation.

South America.—F. C. Lincoln[1] describes the mill of the Incaoro Gold Mine at Pallaya, Bolivia. Ore treatment at the Santa Domingo mine, Peru, is by all-sliming cyanide process.[2] The ore averages $750 per ton. A Dodge crusher breaks the ore to 1-in. size, which is further reduced to 30 mesh by two Huntington mills. On account of clayey material, 30 per cent. of the ore will pass 300 mesh on being ground, so the mills crush 20 tons each per day. The pulp flows to a Dorr classifier where it is joined by 80 tons per day of old $8 tailings, which receives preliminary treatment before reaching the classifier. From the classifier the slime goes to Frue vanners and the sand to a Chalmers & Williams tube mill. The slime is thickened in Dorr thickeners and agitated in two sets of three 15 by 38-ft. Pachuca tanks. Pulp is filtered by an Oliver filter and precipitation is on zinc shavings.

Australia.—Treatment of sulphide ore at the Yuanmi mine, Western Australia, is described as follows:[3]

"The ore, after drying, is crushed in a No. 8 Krupp ball-mill, and roasted in an Edwards duplex furnace with 60 rabbles. Cyanide solution is then added, and the roasted and oxidized ores are mixed, classified, and re-ground together in a tube mill. The ore is finely ground but not slimed, about 14 per cent. being +150 mesh. The ground pulp then flows to mechanical thickeners, the resulting pulp being agitated. It then passes to a vacuum filter of the fixed-leaf gravity-filling type.

"Typical analyses of the ore treated are as follows:

Contents.	Sulphide, Per Cent.	Oxidized, Per Cent.
Insoluble	70.64	80.26
Fe	8.30	9.46
Sb	0.21	0.09
As	0.96	0.37
S	5.62	0.02
Co	Trace	.....
MgO	2.74	.....
CaO	3.36	0.26
Al_2O_3	2.02	5.09
Alkalies, etc.	6.15	4.45

"The gold is very fine, but even in the oxidized ore is not always readily amenable to treatment by cyanide.

[1] *Min. Sci. Press*, April 4, 1914, p. 561.
[2] *Min. Sci. Press*, 109, 181.
[3] *Min. Sci. Press*, 109, 995.

"Oxidized ore from certain portions of the mine has the gold locked up in a hard, flinty matrix, impermeable to cyanide solution. To obtain a good extraction from this particular class of ore, either very fine grinding or roasting is required, the latter being the process adopted here. Experiments have shown that extraction can thus be increased in some cases to from 56 to 96 per cent. with roasting.

"With sulphide ore a thorough roasting is preferable, as the solution does not then foul. This does not appear to be indispensable, the addition of lead acetate and lime having marked corrective effects in cases of an imperfect roast.

"Sulphocyanides are frequently present in the plant solution, and some trouble has been experienced with precipitation due, probably, not so much to these impurities as to small quantities of arsenic and antimony. The precipitation troubles have been eliminated by substituting zinc dust in place of shaving, a special type of extractor having been designed for this purpose.

"Laboratory tests show that extraction is largely effected by fine grinding, sweet roasting, agitation, if not too thick a pulp, and the addition of lime and lead acetate.

"The presence of unroasted sulphide ore in roasted or oxidized pulp lowers the possible extraction.

"The antimony and arsenic are not totally removed by roasting but, being oxidized, they do not prevent a good extraction.

"Attempts to treat the unroasted sulphide ore by the Gitsham process proved unsuccessful. Other methods have also been tried, but so far without success.

"Typical sulphur determinations are as follows:

Before Roasting.		After Roasting.	
Total Sulphur, Per Cent.	Soluble Sulphur, Per Cent.	Insoluble Sulphur, Per Cent.	Total Sulphur, Per Cent.
3.64	0.54	0.02	0.56
4.07	0.65	0.27	0.92
4.53	0.75	0.21	0.96
3.80	0.69	0.20	0.89

"During the 12 months ended August 31, 1914, 49,954 tons of mixed oxidized and sulphide ore was crushed and treated, the residue averaging $1.48 per ton, the extraction obtained being 83.5 per cent. The tonnage handled was low, owing to the mill being closed down for a period of 77 days while the workmen were on strike.

"The following table shows the proportions, etc., of oxidized and sulphide ore treated:

	Oxidised.	Sulphide.
Tons crushed and treated	30,111	19,843
Residue	$1.20	$1.90
Extraction, per cent	83.7	83.3

Philippine Islands.—C. M. Eye[1] discusses the development of gold milling in the Philippines. He gives an interesting description of the early attempts at milling and describes in detail the work at the Minnesota mill of the Benguet Consolidated Mining Co. at Antimok, Benguet, and the mill at the Colorado mine in the Arovoy district, Island of Masbate.

Mexico.—Robert Linton[2] describes the treatment of ore from the Sierra Consolidated Mines Co. at Ocampo, Mexico. The ore is practically all argentite, with some gold carried in a siliceous gangue. He gives an account of the experimental work upon which the plans for the new mill were based.

Costs of Milling

Detailed costs of milling have been published for the following properties: Mexican mill, Virginia City, Nev.;[3] Junction mine, New Zealand;[4] Strattons Independence mill, Colo.;[5] Kalgurlie mill, Australia;[6] Victorious mill, Australia;[7] Porcupine Crown mill, Porcupine;[8] Yuanmi & Oroya Black mine, Australia;[9] concentrate treatment costs at the Treadwell cyanide plant;[10] Hollinger Gold Mines, Ltd.;[11] Tonopah Belmont Development Co., Nev.;[12] Wasp No. 2, Black Hills;[13] Montana-Tonopah Mines Co., Nev.;[14] Tigre Mining Co., Mexico;[15] concentrate treatment costs at Goldfield;[16] milling costs at Goldfield;[17] Nipissing Low Grade mill, Nipissing;[18] Pittsburgh Silver Peak mill, Nev.;[19] Motherlode Sheep Creek mill, British Columbia;[20] Hill Top mill, Nev.[21]

[1] *Min. Sci. Press*, 109, 287.
[2] *Bull. Amer. Inst. Min. Eng.*, Feb., 1914.
[3] *Min. Sci. Press*, Mar. 7, 1914.
[4] *Min. Sci. Press*, Aug. 28, 1914.
[5] *Min. Sci. Press*, 110, 29.
[6] *Min. Sci. Press*, 110, 29.
[7] *Min. Sci. Press*, Apr. 4, 1914.
[8] *Min. Sci. Press*, July 18, 1914.
[9] *Min. Sci. Press*, 109 995.
[10] *Min. Sci. Press*, 109, 960.
[11] *Eng. Min. Jour.*, 97, 665.
[12] *Eng., Min. Jour.*, 97, 1105.
[13] *Eng. Min. Jour.*, 97, 1106.
[14] *Eng. Min. Jour.*, 97, 1254.
[15] *Eng. Min. Jour.*, 98, 1047.
[16] *Eng. Min. Jour.*, 98, 440.
[17] *Eng. Min. Jour.*, 98, 440.
[18] *Eng. Min. Jour.*, 97, 327.
[19] *Eng. Min. Jour.*, 98, 599.
[20] *Met. Chem. Eng.*, 12, 492.
[21] *Colo. School of Mines Mag.*, 4, 55.

GRAPHITE

By Benjamin L. Miller

History of Graphite.—Graphite is supposed to have been recognized by the ancient peoples, as pieces are said to have been found in their graves and some of their pottery was colored with graphite. Its general use, however, seems to have come many centuries later and the earliest recorded mention discusses its use for drawing. It seems, however, that it was used long before in the manufacture of pots and crucibles, as vessels composed in part of graphite have been found in pre-historic graves in Germany. Cennino di Rrea Cennini, an Italian painter of note who lived from 1360 to 1437, is the author of the oldest modern work on the technical processes of painting, entitled "*Trattato della pittura*," in which it is claimed that the earliest reference to graphite occurs. He describes a pencil composed of two parts of lead and one part of tin which he used in his work. The "lead" was probably graphite although this is not at all certain. Cennini may have used the term "lead" in its present sense as it is well known that ordinary lead will leave a mark on paper.

Agricola (1495–1550) describes refractory crucibles made of graphite and it seems that they were generally used by the old alchemists in their attempts to find some method for transforming the baser metals into gold.

In 1565 Conrad Gesner published his famous work on fossils and minerals entitled "*De Rerum Fossilium, Lapidum et Gemmarum maxime, figuris & similitudinibus Liber*," in which (pp. 104–105) the following passage appears: "*Stylus inferius depictus, ad scribedum factus est, plumbi cuiusdam (factitj puto, quod aliquos Stimmi Anglicum vocare audio) genere, in mucronem dera si, in manubri um ligneum inserto.*"

The graphite used in the pencils described by Gesner seems to have come from the graphite mines of Borrowdale, England, which were opened about 1554 and furnished a fine grade of material for about three centuries. The graphite occurred in rather large masses and small pieces were carefully cut and placed in grooved pieces of wood in much the same way that lead pencils are now made.

For a long time graphite was confused with lead and two of its common names, "black lead" and "plumbago" (Latin, *plumbum* meaning lead), indicate its supposed relationship to lead. This was probably due to its

metallic luster, which suggests a metal. The German chemist, Heinrich Pott, who lived between 1692 and 1777, proved that graphite was distinct from lead.

For many years after Pott's work had shown that graphite and lead were distinct, graphite and molybdenite were confused. Karl Wilhelm Scheele[1] in 1799 determined its true chemical composition and proved it to be pure carbon.

The German mineralogist and geologist, A. G. Werner,[2] in 1789 proposed the name "graphite" from the Greek word meaning "to write." Since that date the name has been used more than any other name although it is still called plumbago, black lead, kish, plombagine, potelot, aschblei, reissblei, fercarbure, crayon noir, carbo mineralis, etc. In this country the terms graphite, black lead, and plumbago are all in use and while they all refer to the same mineral, it is interesting to know that there is some slight difference in their use. This is well stated by Malcolm McNaughton,[3] in the following passage:

"While these terms are synonymous, there have come to be certain peculiar applications in their uses—thus, we import "Plumbago" from the island of Ceylon, and "Black Lead" from Germany, Austria and Italy, and, at the same time, we export "Graphite" from this country to all other countries of the world. There are lead pencils, plumbago crucibles, and graphite lubricants; black lead stove polish, plumbago foundry facings, and graphite paint. This confusion of names may seem to be somewhat misleading at times, but there is considerable method in it."

The earliest uses of graphite were for the manufacture of crucibles in the fifteenth century and for pencils in the latter part of the sixteenth century. These two uses for many years were the only ones and there was a limited demand for the mineral. Within recent years many new uses have been found for this interesting mineral and consequently search has been made for it in all parts of the world with a considerable degree of success.

Graphite Industry During 1914

The general condition of the graphite industry during 1914 was far from satisfactory. The high prices that prevailed during 1913 did not have a wholesome effect on the industry, as they tended to demoralize the market by causing the buyers to purchase in smaller quantities and to seek new sources of supply. During the early part of the year the prices fell, owing mainly to the world-wide business depression. During

[1] K. Vet. Akademieus Handlingar, Stockholm, 1799.
[2] *Bergmannisches Journal*, 880, 1789.
[3] *Stevens Institute Indicator*, Jan., 1901, and *Graphite*, May, 1901.

the latter half of the year the situation was worse than for many years, on account of the European war.

Few mineral products are more international in character than graphite. Graphite is found in considerable quantities in practically every country, and yet each country is dependent upon several other countries for the supply of graphite required for the manufacturing industries. The United States contains sufficient graphite to supply not only the entire country but most of the other countries as well. Similar statements could be made in regard to several other countries. In spite of this, the local graphite deposits of each country furnish only a small proportion of the entire amount consumed. The reason for this peculiar situation is due to several causes which may be described under the following heads: difference in physical character of the graphite, presence of impurities, and conservatism of the graphite manufacturers.

Few natural mineral products present greater variability in their physical characteristics than the mineral graphite. These features are so largely dependent upon the past geologic history of the region where the deposits occur that a graphite expert with almost unfailing accuracy can name the locality from which any specimen of commercial graphite has come. A few examples will illustrate this feature. In the case of the Rhode Island graphite we have merely a bed of coal which by regional metamorphism has lost so much of its volatile matter that it will no longer burn with sufficient ease to be regarded as a fuel. On the other hand, much of the carbon has not been converted into graphite. Material of that character would be useless for the manufacture of refractory articles. In northern Mexico there are beds of coal that have locally been metamorphosed by contact with igneous rocks into a high-grade amorphous graphite that is admirably adapted for the manufacture of lead pencils but is practically useless for crucibles or lubricants. In the metamorphosed gneisses, schists, marbles and quartzites of the United States and other countries there are contained thin flakes of graphite, in some cases showing distinct hexagonal outlines, and possessing high luster. This variety is known as flake graphite. Although used for crucibles, lead pencils, etc., to a limited extent, its principal value is in the manufacture of lubricants, paints and stove polish. The compact, thin flat plates render it highly desirable for these purposes, whereas soft, amorphous graphite would be much less serviceable. The physical character of the Ceylon graphite which occurs in well-defined veins in metamorphic rocks and breaks into thick irregular flakes or in needle-like masses is especially suited for the manufacture of durable crucibles and thus far no large deposit of similar material has been found elsewhere.

The impurities present in the graphite also limit the use for various purposes. Only one example of this will be given. The almost universal distribution of mica in flake graphite deposits is one of the chief obstacles to the use of this variety of graphite for the manufacture of refractory articles. While part of the mica can be removed by the various concentrating processes now in use, it is impossible to remove all without a very considerable loss of graphite. This is an additional reason why flake graphite is so little used in the manufacture of crucibles.

The conservatism of the manufacturers of graphite articles is another factor of great importance in the determination of the market conditions of graphite. Madagascar graphite may, for many purposes, be as suitable as the Ceylon product, or Korean graphite may be adaptable for some uses for which Mexican material has long had the preference, just as many years ago the graphite from Borrowdale, England, was thought to be the only material suitable for lead pencils, but graphite users are extremely loath to accept the product of new regions.

As a result of the conditions mentioned above, no country manufacturing diverse kinds of graphite articles is independent, regardless of the abundance of the graphite deposits it possessses, for as yet no country produces all the various kinds of graphite which the trade demands.

This condition of affairs has been responsible for the practical stagnation of the graphite industry since the outbreak of the European war. As the bulk of the world's supply of graphite comes from Ceylon, Madagascar, and Korea, countries belonging to the allies, it was only natural that embargoes should be placed on the shipment of any graphite to Germany or Austria. Somewhat later England and France prohibited the sale of graphite from Ceylon and Madagascar to any neutral countries, fearing that it might ultimately reach Germany. The result of these embargoes was the almost complete suspension of graphite mining in these two islands during the latter months of 1914. What effect this has had in Germany, where graphite crucibles are necessary for the manufacture of crucible steel, has not been learned. It is probable that the deposits of Passau, Bavaria, have been worked much more energetically than in former years. The graphite manufacturers of the neutral countries suffered inconvenience in the last months of 1914 as the available supplies of Ceylon and Madagascar graphite were soon exhausted, but the most serious consequences will be felt in 1915.

Graphite in Foreign Countries

British Honduras.—According to Garrard Harris, Belize, "at Manatee, 18 miles south of Belize, and in the foothills of the Cockscomb Range of mountains, there has been discovered an extensive deposit of graphite

pon a 12,000-acre tract of land, the property of a citizen of Belize. urface prospects indicate that the bed is a large one. There is also con-iderable heavy ore, which is as yet unanalyzed, but which has been pro-nounced to be lead ore. It is said to exist in workable quantities."

Canada.—Only a few of the numerous graphite mines of Canada were in operation during 1914. The Black Donald of Calabogie, Ontario, was the principal producer. Part of the material was good flake suitable for crucibles, but much of it was of inferior grade and used mainly for foundry purposes. The Tonkin-Dupont Company of Wilberforce, Ontario, also shipped a few carloads of graphite.

The following brief article in the *Canadian Mining Journal* of June, 1914, describes a new operation: "The graphite deposits at Elmsley, Ont., which were extensively operated several years ago, will be taken over by Pittsburgh people. The mill will be overhauled and its capacity, which is now 60 tons per day, increased to 100 tons. About 6 per cent. of graphite is extracted by the present machinery. This will be increased to 8 per cent. by the installation of some new separation tables. These properties were intermittently operated for the last 20 years. Diamond drill borings have shown that the extent of the deposits is great."

Ceylon.—The graphite industry of Ceylon was greatly distributed throughout the entire year of 1914. The condition during the first part of the year is shown by the brief articles by Sydney S. Sedwick, superintendent of important graphite mines at Medapola, published in a local Ceylon paper on July 24, 1914.

"Recently there has been exhibited a considerable amount of nervousness with regard to the apparent falling off in demand for plumbago, and wild speculations have been made as to the cause. The most universal one has been that Madagascar was usurping the position previously held by Ceylon. While not detracting from the power of Madagascar to eventually prove a most formidable competitor, I think we must look elsewhere for reasons for the present state of the market.

"Ceylon's production has averaged, roughly, 30,000 tons a year. The world's consumption of graphite calls for the production of over 00,000 tons. Of this the average consumption by the United States ne is 16,000 tons. The world's consumption for crucibles alone ounts to practically 54,000 tons and, roughly, 5600 tons for stove sh and foundry facings. The demand has been constantly on the ase. Fifteen years ago 75 per cent. of the world's supply was used ucibles and 4 per cent. for lubricants; now 30 per cent. goes into nts and 50 per cent. for crucibles. A point that must be borne in that graphite differs from other minerals in that it can not be used

twice. Whether taken for crucibles, lubricants, stove polish, pencils, foundry facings, paints, shot and powder polishing, electrical purposes, or by carbon manufacturers, it can never be used a second time.

"Madagascar produced last year 8000 tons of plumbago, of which 6314 tons were exported, this exportation having risen from 19 tons in 1909. I have not the exact figures, but a considerable proportion of this plumbago was taken by France for making lubricants and would, therefore, not affect the Ceylon supplies to any great extent. To counteract the Madagascar output, the mines in Austria, which produced large supplies of plumbago, have become nearly exhausted and several large producers have stopped altogether. The exports from Mexico to the United States have been practically nil, owing no doubt to the unsettled state of the country. From these figures I think it will be seen that the present conditions are not due to Madagascar competition. The real reason lies in the unsettled state of the general situation throughout the world. Last year nearly every industry was booming, with the result that Ceylon plumbago reached the highest prices since 1899 and there was even a scarcity of the article. Manufacturers now, in the unsettled state of markets, will not lay in stocks, but prefer to work on the narrowest possible margin. Once these conditions change there is no doubt there will be not the slightest difficulty in disposing of the Ceylon output and there are already indications pointing to an early improvement. At the present time there would be far more plumbago from Ceylon going into consumption were it not for the wild speculation in the mineral last year by numbers of small dealers, who can not afford to sell at the prices now ruling without making heavy losses. The prices offered for Ceylon plumbago even now compare favorably with those obtained at the end of 1906 and those ruling through 1907. Plumbago is analogous to rubber in that the boom last year did infinitely more harm than good. In Canada, America, France, Austria, and Norway, and in fact in most mineral countries, ore is found containing an admixture of small flake or crystalline graphite, together with amorphous graphite. These deposits, owing to the erection of costly plants for crushing and concentrating, can only pay when the prices reach the standard of last year, but when they are once started it takes time to knock them out of competition. Every manufacturer would prefer Ceylon plumbago if it can be obtained at a reasonable price.

"The stocks of plumbago actually in Ceylon now are considerably less than they were even 2 years ago. Two years ago you could visit practically any mine and see stocks of plumbago at the mine itself, which, taking the aggregate of the mines then working, amounted to some thousands of tons. In very few instances will you find that the case now.

Even the stocks in Colombo are considerably less than formerly and in several instances are nearly all sold. The question is more serious from the point of view of the production not meeting the demand at reasonable prices than for the Ceylon output to be a drug on the market. The production from the mines of Ceylon will certainly be 10,000 tons less this year than last year. That alone counterbalances the Madagascar output and taken in conjunction with the small stocks held both here and abroad the question of overproduction is a myth. There seems little prospect of the output being increased.

"While plumbago was being mined at very little depth, the native methods of mining were satisfactory for the time being, and required very little initial outlay. Now, it is necessary to install pumping and hoisting machinery and it is only the wealthy Singhalese who care to do this and who will undertake the risk. Even then, with one or two notable exceptions, the propositions are very difficult to tackle and require a big expenditure of money owing to the previous primitive methods of mining. The old native method of mining was to follow down on the vein and to open no levels at all. Installing machinery necessitates good deep level shafts with proper levels opened to facilitate the haulage and the ventilation. In a number of Ceylon mines to do this would be attended with great risk. No survey has been made of the mines, so that in rising up on the vein to the higher levels, you are liable to suddenly break into old workings standing full of water or even into old disused shafts, and sacrifice a number of lives.

"For mines in Ceylon which can produce plumbago at a reasonable cost, the outlook with regard to sales should always be promising. But if the prices soar up to those of last year, the manufacturers will take only the highest grade of Ceylon plumbago and will mix it with the flake plumbago obtained from the masses of disseminated ore existing in the crystalline limestone and the amorphous graphite, of which there are great bodies existing in different parts of the world. The cost of labor in Ceylon compares very favorably with other parts of the world, and the labor would be ample for all requirements if the Government would only insist on some form of sanitation. As things are allowed to go on now, you will find on several mines hundreds of coolies herded together on perhaps half an acre of land with no sanitary arrangements whatever, the consequence being, especially in the dry season, that the bulk of the coolies are down with dysentery and fever. In the mining regulations it is only laid down that proper sanitary measures shall be taken 'within the mine' and I understand the attorney general's definition of this is to mean underground, while the question of sanitation for mines is far more imperative than on a tea or rubber estate."

On Oct. 23, 1914, the British government placed an embargo on Ceylon graphite, preventing it from going to any country other than those of the allies. Importers in the United States for a time were able to obtain the product by way of England but a later embargo forbade any shipments from English ports to other countries. The result of these regulations has been the closing of all the leading markets of the world for Ceylon graphite, which has forced almost all the Ceylon mines to close.

The following table compiled from the half-yearly reports sent in for January, 1913, July, 1913, and January, 1914, shows the number of mines worked and the number of men employed; it is an average of the three periods:

Province.	Number of Mines.	Number of Men.
Western	222	2277
Central	14	195
Southern	893	2761
Northwestern	37	1528
Sabaragamuwa	169	2792
Total	1335	9553

Germany.—In the early part of 1914 attention was directed to the graphite deposits of Passau, Bavaria. The graphite, which is of the flake variety, occurs in a gneiss and is similar to that of the New York and Pennsylvania regions. Although inferior to Ceylon graphite in the manufacture of crucibles, it has long been used for that purpose. No doubt the embargo placed on the exportation of Ceylon and Madagascar graphite by the British and French governments has stimulated production of the Bavarian product.

Italy.—The graphite production of Italy has been diminishing, according to a leading graphite importer, who estimates the 1914 output at approximately 2000 tons. Nearly all the material is used for foundry facings.

Korea.—Korea contains numerous deposits of both amorphous and flake graphite but up to the present time practically all the material produced belongs to the former class. During 1914 the production remained about the same as in the preceding year, some mines closing down on account of the exhaustion of the best material, while a few mines were opened. With few exceptions the material is all shipped to Japan, from which place much of it is trans-shipped to other countries.

Madagascar.—The condition of the graphite industry in Madagascar was extremely unsatisfactory during 1914. For several years previous each year had shown a remarkable increase in production, while the year

4 showed a considerable decrease. The embargo placed on the ex-
tation of the product by the French government in the latter part of
ober was mainly responsible for this state of affairs. In addition to
, however, the industry was injured by several shipments of inferior ma-
al, which had the tendency to make the trade suspicious of all Mada-
car graphite. Some material was shipped to Europe that was of such
r quality that no buyers could be found before the opening of the
. The situation is an unfortunate one because there is no question
he high character of much of the graphite produced in that island.
the present time Madagascar is the only serious competitor of Ceylon
large quantities. Ceylon producers recognize the situation and seem
be inclined themselves to substitute Madagascar graphite for the
lon product. Under date of May 15, 1914, the U. S. Consul writes
ollows: "A peculiar feature is that, though the demand from the
ted States is made to appear unnaturally small, nevertheless certain
l dealers are attempting to buy stocks in Madagascar for import into
lon. As this island uses practically no plumbago, Madagascar
ks can be imported only for re-exportation to the United States or to
many when better prices prevail. In other words, it is thought that
se dealers will buy under cover on the local market while the prices
low, confident that in a very short time the demand from the United
tes and Germany will become much stronger."

The graphite mines of Madagascar are all shallow open-cut workings,
deepest being no more than 80 ft. The rock mined thus far is
atly decayed, rendering the process of concentration a relatively easy
. After washing in water to remove the fine mud the material is
d and then freed from the particles of quartz by a pneumatic process.

The prices obtained for Madagascar graphite vary greatly. One
ter states that the prices vary, not only with the carbon content,
character and size of the grains, the nature of the impurities, etc.,
also with each buyer and each shipment. As an example it is said
t a shipment averaging 95 per cent. carbon sent to London was sold
$120 a ton, while some material containing 70 to 80 per cent. carbon
t to several firms in France was sold at prices ranging from $25 to
per ton.

Mexico.—Notwithstanding the continuation of the revolution,
xico produced about its normal output of graphite during 1914.
e U. S. Graphite Company was the only producer.

United States

The graphite industry in the United States still remains in an un-
isfactory condition; of the scores of graphite mines distributed over

eighteen states and Alaska less than a dozen were operated during 1914. The producing states were Alabama, California, Montana, New York, Pennsylvania and Rhode Island. In Michigan, where graphite slates are quarried for paint purposes at L'Anse, Baraga County, no production was made in 1914, as a sufficient supply for all demands was on hand from 1912.

STATISTICS OF GRAPHITE IN THE UNITED STATES

Year.	Refined Crystalline Graphite.						Amorphous Graphite Production.	
	Production.		Imports.		Consumption (a).			
	Pounds.	Value.	Pounds.	Value.	Pounds.	Value.	Tons, 2000 lb.	Value.
1900	4,103,052	$164,122	32,298,560	$1,389,117	36,401,612	$1,553,239	1,045	$8,640
1901	3,967,612	135,914	32,029,760	895,010	36,997,372	1,067,921	809	31,800
1902	4,176,824	153,147	40,857,600	1,168,554	45,034,424	1,322,401	4,739	55,964
1903	4,525,700	164,247	32,012,000	1,207,700	36,537,700	1,371,947	16,591	71,384
1904	4,357,927	162,332	25,350,000	905,581	29,707,927	1,067,913	19,115	102,925
1905	4,260,656	170,426	34,914,611	983,034	39,175,267	1,153,460	(b)21,953	80,639
1906	4,894,483	170,866	50,974,336	1,554,212	55,868,819	1,725,098	(b)16,853	(c)
1907	4,586,149	149,548	40,962,000	1,777,389	45,548,149	1,926,937	(b)26,962	138,381
1908	3,433,039	149,763	22,912,714	762,267	26,345,753	876,030	(b) 1,433	75,250
1909	5,669,899	340,194	42,532,851	1,854,459	48,202,750	2,194,653	(b) 5,096	32,238
1910	5,625,132	286,882	50,610,560	1,872,592	56,235,692	2,159,474	(b) 1,407	39,710
1911	4,790,000	256,050	41,404,000	1,495,729	46,194,000	1,751,779	1,223	32,415
1912	3,543,771	187,689	51,286,000	1,709,337	54,829,771	1,897,026	2,063	32,894
1913 (b)	5,064,727	254,328	57,758,400	2,109,791	62,823,127	2,364,119	2,243	39,428
1914	.....	.....	44,004,800	1,398,261	.....	.....	.....	.....

(a) Neglecting the small re-export of foreign product. (b) Statistics of the U. S. Geological Survey. (c) Not reported.

Alabama.—Four graphite companies were in operation during 1914—the Quenelda Graphite Company located about 8 miles west of Ashland, the Ashland Graphite Company located about 4½ miles west of Ashland, the Flaketown Graphite Company located about 3½ miles northeast of Mountain Creek station, and the Jennings Graphite Company of Lineville. The latter company is a new producer, while the others have been in more or less continuous operation for several years.

All of the Alabama graphite is of the flake variety and is contained in metamorphic schists and gneisses of sedimentary origin. The ore contains some mica and also some earthy material between the laminæ of the flakes which are only removed with difficulty. Nevertheless some high-grade flake graphite is produced.

California.—Graphite occurs in several different places in California but has been worked in but few localities and there only to a small extent. Most of the material produced is amorphous and consequently unsuited for crucibles. Most of it has been utilized for foundry facings. In 1914 a few tons were mined near Los Angeles.

Montana.—The best graphite produced in the United States is that of the Crystal Graphite Company of Dillon, Montana. This is more

nearly like the Ceylon graphite than any other occurring in this country and part of it can scarcely be distinguished from the Ceylon product. Unfortunately the deposit is situated in a rugged region about 9 miles from Dillon and transportation costs are high. Also the veins of graphite are thin, seldom more than 6 in. in thickness. While the material thus far mined is somewhat softer than that from Ceylon and hence crumbles to a greater extent in shipment, it is believed that deeper workings will show a firmer grade. During 1914 one car of graphite averaging about 75 per cent. carbon was shipped, while an additional amount was mined for shipment. The development of this mine is being watched with interest by graphite consumers.

New York.—For many years New York has been the leading graphite-producing state, due to the extensive operations of the Joseph Dixon Crucible Company in their mine at Graphite, a few miles west of Lake George. Although the State contains graphite in many places and numerous companies have been organized at different times to operate the deposits, only this one mine has proved successful. The ore occurs in an impure metamorphosed quartzite averaging about 6 per cent. graphite. The bed of ore is regular and, dipping at a low angle, is mined in the same manner as a bed of coal except that no timber is required. Occasional pillars of the graphite-bearing rocks are left as supports for the overlying beds. The graphite is freed from the bulk of the associated minerals at the mill located near the mine and then hauled to Ticonderoga for further refinement.

Pennsylvania.—Nearly all the graphite mines of Pennsylvania were idle during 1914, two only reporting any production. These, both located in Pickering Valley, Chester County, are the Rock Graphite Mining and Manufacturing Company of Chester Springs, and John H. Lilly of Byers who has leased the property long known as the Pennsylvania Graphite Company's mine. The former company had been idle for several years, although the mill remained in good condition. The rock mined is a fairly fresh graphitic gneiss containing a good quality of flake. Mr. Lilly rebuilt the mill on his property, which was destroyed during the latter part of 1913, and operated it part of the time. The combined production from the two mines was small.

The mine of Pettinos Brothers near Byers has remained idle since the destruction of their mill August 2, 1913. For many years this mine furnished the principal production of Pennsylvania and was the most steady producer.

Rhode Island.—For many years there has been a small output of amorphous graphite from a mine near Providence, Rhode Island. The material mined is a volatile substance and averages from 25 to 40 per

cent. carbon. During 1914 only a small amount was produced, all of which was used for foundry facings.

Manufactured or Artificial Graphite

Owing to the general commercial disturbances of the year, the International Acheson Graphite Company of Niagara Falls, N. Y., failed to maintain its usual record for increased production of manufactured graphite during 1914. This graphite is suitable for many purposes and is an important competitor of the natural graphite. The bulk of the output is utilized in the manufacture of electrical supplies and lubricants.

PRODUCTION OF MANUFACTURED GRAPHITE 1899–1914

Year.	Quantity, lb.	Value.	Price per Pound, Cents.
1899	405,870	$32,475	8.00
1900	860,750	68,860	8.00
1901	2,500,000	119,000	4.76
1902	2,358,828	110,700	4.69
1903	2,620,000	178,670	6.82
1904	3,248,000	217,000	6.70
1905	4,595,500	313,979	6.83
1906	4,868,000	312,764	6.42
1907	6,924,000	483,717	6.97
1908	7,385,511	502,667	6.80
1909	6,870,529	467,196	6.80
1910	13,149,000	945,000	7.19
1911	10,144,000	664,000	6.54
1912	12,896,347	830,193	6.44
1913	13,633,342	973,397	7.14
1914	10,455,139	.....	....

WORLD'S PRODUCTION OF GRAPHITE
(In metric tons)

Year.	Austria.	Bavaria.	Canada.	Ceylon. (a)	India.	Italy.	Japan.	Mexico. (b)	Sweden.	United States. (c)	France and Colonies
1900	33,663	9,248	1,743	19,168	1,859	9,720	94	2,561	84	1,799	.....
1901	29,992	4,435	2,004	22,707	2,530	10,313	88	762	56	1,800	.....
1902	29,527	5,023	993	25,593	4,648	9,210	97	1,434	63	1,895	.....
1903	29,590	3,719	660	24,492	3,448	7,920	114	1,404	25	2,053	.....
1904	28,620	3,784	410	26,478	2,955	9,765	216	970	55	2,045	.....
1905	34,416	4,921	491	31,134	2,361	10,572	209	970	40	1,933	.....
1906	38,117	4,055	405	36,578	2,642	10,805	177	3,915	37	2,220	.....
1907	49,425	4,033	525	33,027	2,472	10,989	103	3,202	33	2,080	.....
1908	44,425	4,844	227	26,227	2,919	12,914	177	1,076	66	1,557	300
1909	40,710	(e)4,900	783	25,995	3,182	11,583	284	1,704	26	5,875	320
1910	33,131	7,415	1,263	30,008	4,319	12,510	145	2,332	49	3,811	1100
1911	41,599	11,298	1,154	27,433	4,047	12,621	114	2,974	65	3,280	1870
1912	45,375	12,532	1,873	33,106	Nil.	13,170	149	2,865	79	3,318	5600
1913	49,456	.....	1,961	29,277	.....	11,145	.....	1,057	88	4,331	(e)7000
1914	.....	.....	1,494	.....	.....	.....	.....	.....	.....	.....	.....

(a) The figures for 1897, 1899, 1907, 1908, 1912 and 1913 are exports; the enormous production in 1898 as reported in official government publications is not reflected in the exports of that year which amounted to 24,349 metric tons. (b) Exports. (c) Crystalline graphite up to 1909. (d) Includes the production of 7520 metric tons in Korea. (e) Estimated.

GYPSUM

By Frank A. Wilder

The most notable publication of the year dealing with gypsum and its products was issued by the Canadian Department of Mines: "Gypsum in Canada, its Occurrence, Exploitation and Technology," by L. C. Cole. The earlier chapters deal with the chemical nature and theories in regard to the origin of gypsum. Part Two, after giving statistics of gypsum production, describes the occurrence of gypsum in Nova Scotia, New Brunswick, Quebec (Magdalen Isles), Ontario, Manitoba, Elberta and Northwest Territories, and in British Columbia. It further gives a history of the plaster industry in each of these provinces, and describes the mines and mills that were in existence at each producing point in Canada in 1913.

Part Three describes mine and quarry methods and devotes 30 pages to the technology of gypsum and gypsum plasters, and considers at some length the various fields of usefulness into which gypsum and gypsum products enter.

The following paragraphs are taken from the introduction to this volume.

"During the year 1912 nineteen companies were engaged in the quarrying or mining of gypsum in Canada. Nine of these companies produced crude gypsum only, most of which was exported to the United States for manufacture into the finer grades of plaster of Paris. During the early part of 1911 there were six calcining plants in Canada operating, in all, 13 kettles. At the close of the same year two new plants started and two companies, already operating, have enlarged their plants, so that 18 kettles are now running. One plant is using Cummer kettles as preliminary dryers, preparatory to calcining in kettles, and two plants are using other types of dryers. In three cases the gypsum was obtained from mines and the rest from quarries. The material in all cases but one was gypsum rock, either white or gray. The single exception was the small production from British Columbia, which was a high-grade gypsum earth.

"The gypsum industry of Canada consists, chiefly, in quarrying the crude gypsum and in shipping it in that state to the United States. There it is calcined and, in part, shipped back to Canada as a finished product. The industry on the whole is gradually increasing, but, as

regards the extent to which calcining is at present carried on in Canada, there is still ample opportunity for growth. Even with the mills already operating at their full capacity, there is still a considerable quantity of the finished product being imported from the United States.

"It is only recently that any endeavor has been made to place the advantages of the hard wall plasters before the public; yet, by demonstrating the method of application of these plasters, and by means of advertising pamphlets, describing their adaptability for different uses, the producers could readily increase the volume of their sales. Concerted effort along this line by all producers manufacturing in Canada would greatly benefit the industry."

CRUDE GYPSUM MINED IN THE UNITED STATES (a)
(Tons of 2000 lb.)

1880	90,000	1892	256,259	1904	940,917
1881	85,000	1893	253,615	1905	1,043,202
1882	100,000	1894	239,312	1906	1,540,585
1883	90,000	1895	265,503	1907	1,751,748
1884	90,000	1896	224,254	1908	1,721,829
1885	90,405	1897	288,982	1909	2,252,785
1886	95,250	1898	291,638	1910	2,379,057
1887	95,000	1899	486,235	1911	2,323,970
1888	110,000	1900	594,462	1912	2,500,757
1889	267,769	1901	633,791	1913	2,599,506
1890	182,995	1902	816,478		
1891	208,126	1903	1,041,704		

(a) Statistics of the U. S. Geol. Surv.

Bulletin 580E of United States Geological Survey, by Geo. E. Kay, gives a brief description of gypsum found at Centerville, Iowa. Centerville is near the northern boundary of the state, while Fort Dodge, one of the important gypsum centers of America, is located 100 miles to the north.

The gypsum, accompanied by anhydrite, was found in a test hole made by a diamond drill in the coal fields, at a depth of 550 ft. It lies below the coal measures and is regarded as Mississippian in age. Although a shaft has been sunk to the gypsum, no mineral of consequence has been taken out, and although 10 ft. of mixed gypsum and anhydrite seem to underlie a considerable territory, it does not seem probable that this field can compete with the Fort Dodge mills where operating conditions are very much more favorable.

Bulletin 363 of the University of Texas, which describes "The Deep Boring at Spur," gives a description of a rather remarkable series of beds of gypsum and anhydrite, interbedded with dolomite, totaling hundreds of feet. The anhydrite is regarded by its author as both primary and secondary in its nature.

Mr. Rowland Lowe, of the firm of Butterworth & Lowe of Grand

tapids, contributes the following information in regard to the gypsum ıdustry in England, gathered during a visit to the gypsum plants of ıat country in the fall of 1914.

"The well-known British plaster plants are mainly located in the ıiddle and north of England, *i.e.*, at Newark, Nottingham, Carlisle, and ewbiggin. Most of their plaster has hitherto been made by calcining ıe gypsum in lump form and subsequently crushing, grinding and eating it by their special methods to suit the many lines of trade they ıter to. The entire output has been rather small, because hard wall laster for first coatings (taking the place of lime mortar) is only just eing introduced in Britain. When such plaster becomes generally sed there it will probably treble the output of gypsum products.

"About 3 years ago an American (Mr. Culver) went to England and ıstalled the first hard wall plaster plant (and the only one in Britain s yet) at New Biggin, he and several British capitalists furnishing ıe money. It replaced an old-fashioned plaster plant that had been roducing an average of less than 10 tons a day for many years. In ıis new plant they have installed two Butterworth & Lowe self-contained 0-ft. kettles, a 36-in. rotary cracker, an English swing jaw nipper, a ve-spout Broughton mixer, a Ruggles-Coles dryer, and a Raymond ulverizer, all driven by a Crossly producer gas engine of 500 h.p. heir product is mainly hard wall plaster which seems to be meeting with reat success in Britain, as their plant is kept pretty fully occupied (even ı these war times). This is an excellent showing, since it necessitated ıaking a favorable impression on the architects and inducing the uilders to use what is to them an entirely new material for first oatings.

"Their gypsum deposit (located a few hundred feet from their mill) ı about 20 ft. thick under about 15 ft. of soil which is stripped by steam hovel. This gypsum ledge is probably quite extensive, extending for everal miles north toward Carlisle. Such plaster mills as are later uilt in England may grind with buhr mills (which they generally now se and seem to prefer) to avoid the expense and power required for dryer nd pulverizer.

"Thirty miles north, near Carlisle, three small plaster plants of the ld type consolidated some years ago and are now operated by one ompany. Probably the largest British plant is located at Newark, ear the middle of England. Now that the American type of plant ıas proven so successful at New Biggin it seems most likely that in time he other English plaster makers will introduce the American system, at east for a large portion of their products, to secure lower manufacturing osts and more perfect and ajustable calcining. For some special pur-

poses, however, the English manufacturers certainly make beautiful fine plaster, probably as good as any made in America, though at what we should regard as rather high cost of production, considering that wages and fuel will average one-quarter lower than in our Central States."

Mr. Lowe states that his firm is shipping a crushing, grinding and screening outfit complete for a small gypsum plaster plant to be built at Lima, Peru. He adds: "we know but little about plaster making down there, but have learned from the correspondence that there are already one or two small plaster plants in Lima. Their practice there has been to calcine the gypsum rock in pieces of 6- or 8-in. size in a rectangular kiln about 10 ft. square, with clay brick walls. A dry pan or Chilian mill with large wheels grinds these pieces of calcined gypsum, and the product is strained through a gridiron with openings of $\frac{1}{16}$ in., from which it is discharged onto a fine screen consisting of a frame of wood with metal cloth of 46 meshes to the inch placed in a horizontal plane and hanging from four pendants that allow a vibratory oscillating movement back and forth. The coarse powder returns to the Chilian mill to be ground again. Recently there has been installed in Lima a gypsum plaster plant of American method to replace European. In it there are 'two small boilers where they calcine the crude powder of gypsum that they first mill in a Blake pulverizer, and they grind the product in a Ball mill whose product (pulverized and crude) goes to the boilers where it is calcined and sold without passing it through any screen whatever.' The equipment we are sending to Lima is used for reducing gypsum rock which has already been calcined in a square kiln as above stated. These calcined rocks are then crushed in our rotary cracker, then elevated and discharged onto a slanting vibrating screen, the fines from which are commercial plaster of Paris. The tailings from this slanting screen are carried to fine under runner buhr mills which finish the product."

With reference to Australia Mr. Lowe writes: "There are no gypsum plaster plants so far as we know in Australia. Much of their plaster of Paris comes from New Brunswick and Nova Scotia, although "King's Windsor," made at Staten Island, New York, is also well known there. For several years we have corresponded with engineers in Australia and believe that before long American machinery will be sent there to completely equip a gypsum plaster plant."

The European war has brought to American producers numerous inquiries for plaster of Paris for export, and a few thousand tons of such business has been secured by mills near the Atlantic coast. These inquiries have led to a study of building operations in South America with a view to determining the possibilities of trade expansion along

this line. The following paragraphs are taken from an article in *Financial America*, on "Building in Brazil."

"Wooden buildings, even for dwelling houses, are practically unknown in Rio de Janeiro. The average building in the business center of the city is three stories high, and front up to the second story is usually faced with stone or granite, the upper part being built of brick.

"Wooden laths for the inside of buildings are unknown, except in the interior of the country, where they are used to a limited extent. The climate of Rio de Janeiro is so warm throughout the year (the temperature rarely falling below 50° F.) that artificial heating is not necessary, and this is probably one of the principal reasons for the absence of laths in the interior finish of buildings. Inner walls are usually finished by applying the plaster to the brick walls. In the case of partitions (most of these being also of brick, but some occasionally of wood) the plaster is applied directly to the boards. Wire cloth (expanded metal) has grown in popularity for the application of plaster in business buildings as well as residences. This material has in the past been imported chiefly from England, France and Germany.

"Lime used in the manufacture of plaster is locally produced. Prominent architects and builders state that its quality is inferior, but that the use of foreign lime is not possible because of the prohibitive customs duties.

"The use of plaster board for interior finishing is unknown here. Whether it could be successfully introduced and would take foothold as a staple article in construction work in Brazil is a matter of conjecture.

"A campaign for its use would require some initial expenditure on the part of American manufacturers in advertising and in finding enterprising and financially responsible local representatives who would be sufficiently familiar with the buying trade.

"Plasterers, who are also capable of doing fancy decorative work, receive only 7 to 8 milreis per day ($1.75 to $2.00 at the present rate of exchange). The plastering and kindred trades are not organized into unions here."

During 1913 several gypsum producers organized the Gypsum Industries Association, and the following statement of its purposes is presented by its secretary, S. G. Webb, Room 1015, 17 State St., New York City.

"The Gypsum Industries Association was organized in August, 1913, and since that date has been engaged in its avowed purposes of furthering the development and advancement of the uses of gypsum and the advancement of all efforts seeking to bring about a reduction of the national fire waste.

"In furtherance of the above objects the Association has coöperated

with national movements, which have for their object the lessening of the fire waste, by advocating improved methods of construction. Such movements, being engaged in by recognized institutions, include among such institutions the following: National Board of Fire Underwriters, The Underwriters Laboratories, Inc., The National Fire Protection Association, The American Society of Testing Materials, The British Fire Prevention Committee Bureau of Standards, and other institutions.

PRODUCTION OF CRUDE GYPSUM IN THE PRINCIPAL COUNTRIES. (a)
(In metric tons.)

Year.	Algeria. (b)	Canada.	France. (b)	Germany. (c)		Greece.	India.	United Kingdom.	United States.
				Baden.	Bavaria.				
1898.....	37,337	198,864	2,115,261	28,037	25,688	83	8,390	199,174	285,644
1899.....	39,950	221,821	1,807,454	29,419	29,727	81	6,546	215,974	382,891
1900.....	42,237	228,656	1,774,492	26,381	35,484	129	4,415	211,436	439,265
1901.....	44,025	266,476	2,385,633	28,183	3,581	671	(d)	204,045	598,529
1902.....	44,975	301,165	2,185,346	33,150	31,701	*Nil.*	(d)	228,264	740,906
1903.....	41,550	285,242	1,998,804	29,423	30,894	94	(d)	223,426	945,285
1904.....	48,375	309,133	1,957,802	26,984	22,766	393	3,937	237,749	853,546
1905.....	34,743	395,341	1,378,145	28,823	46,247	185	4,877	259,596	982,626
1906.....	27,950	378,904	1,377,429	25,643	50,763	70	(e) 5,000	228,627	1,397,480
1907.....	26,400	431,286	1,316,567	29,153	48,975	70	(e) 5,000	239,285	1,564,061
1908.....	25,500	346,436	1,750,562	35,217	51,314	*Nil.*	(e) 5,000	231,980	1,694,155
1909.....	36,250	398,290	1,655,672	36,621	51,630	191	(e) 5,000	242,832	(f) 2,042,286
1910.....	60,625	481,941	1,980,804	41,078	54,397	249	6,678	259,648	(f) 2,158,756
1911.....	61,502	470,381	2,110,520	42,408	60,390	1,263	9,340	281,111	(f) 2,112,770
1912.....	(d)	524,892	2,150,900	51,777	57,114	127	21,369	247,724	(f) 2,269,290
1913.....	.....	577,442	.....	49,767	.....	2,245	.....	242,341	(f) 2,357,752
1914.....	.....	463,375	.....	.....	.....	.....	.....	.....	.....

(a) From official reports of the respective countries, except the statistics for the United States (b) A part of the product is reported as plaster of Paris. In converting this into crude gypsum it has been assumed that the loss by calcination is 20 per cent. (c) Prussia is a large producer of gypsum but there are no complete statistics available. The output in 1910 was 22,042 tons. (d) Statistic not available. (e) Estimated. (f) U. S. Geol. Surv.

"The Gypsum Industries Association is engaged in very close corporation with such institutions and has been invited, through its officers and members, to act with the above institutions through membership of important committees therein.

"The Gypsum Industries Association has also been engaged in the work of developing information regarding physical facts about gypsum and gypsum commodities, which are essential in connection with the use of such gypsum commodities in construction. These physical facts include resistance to fire and water of gypsum commodities or constructions now used for various purposes, such as partitions, elevator and stairway shaft enclosures, floors, roofs, etc. In addition to the questions of fire and water resistance, investigations have been conducted into heat and sound conductivity, crushing value, impact value, and the best methods of use, including developed types of construction for many specific purposes.

"The Gypsum Industries Association recently determined to enlarge its field of action and its scope of work and influence, and with this object in view has enlarged its membership, so that at present its membership includes by far the larger number of gypsum producers and manufacturers located in the United States and Canada. It has established permanent headquarters in New York and has become an incorporated membership corporation, under the Laws of the State of New York."

New York (By D. H. Newland).—The commercial production of gypsum is carried on at present in four counties—Onondaga, Monroe, Genesee, and Erie. The deposits occur in the belt of salina strata which extends nearly across the state, but they are only of importance in the central and western sections, between Madison and Erie Counties, where the salina formation attains its greatest development. They range from 2 or 3 ft. up to 40 or 50 ft. thick, the maximum being reached in Onondaga County near Jamesville and Fayetteville. The beds in that section, however, are rather impure; they contain shaly layers and the gypsum is intimately intermixed with carbonates and clay so as to be of little value for calcination by itself, although it can be used in mixture with high-grade materials. Most of the rock that is quarried in Onondaga County is sold for agricultural plaster. In the western part the gypsum is only from 2 to 6 ft. thick, but it is on the whole much purer and is used largely for calcined plasters which are prepared in local mills operated by the mining companies. A portion of the output is sold crude to Portland cement manufacturers in New York and Pennsylvania. The rock in the western section is mined underground through vertical shafts or side-hill openings and some of the mines are very extensive and well equipped. Electric power from Niagara Falls is used in some of these mines for haulage and lighting. The production of gypsum during the last 2 years has been as follows:

PRODUCTION OF GYPSUM IN NEW YORK

	1913.		1914.	
	Short Tons.	Value.	Short Tons.	Value.
Total output, crude	532,884	.....	513,094	.....
Sold crude	183,579	$265,879	169,257	$246,804
Ground for land plaster	8,521	17,807	7,096	15,342
Wall plaster, etc., made	306,206	1,022,457	297,084	985,258
Total value	.....	$1,306,143	.....	$1,247,404

There was little change in the mining situation during 1914. The output was about 20,000 tons less than in the preceding year, but still larger than in any earlier period of time. From a financial standpoint

the conditions were not very favorable, as the depression in the building trades in the east curtailed the market for calcined plasters, which resulted in the lowering of prices and keen competition among the mills. No new enterprises entered the field, although the property at Akron, formerly worked by the Akron Gypsum Co., resumed operations as the Akron Gypsum Products Corporation. The Consolidated Wheatland Plaster Co., of Wheatland, whose mill was destroyed by fire in 1913, again entered upon active work during the year.

A good deal of interest has been manifest in prospecting work in the western counties, but so far no new mills are in process of development. Prospecting in that district is attended with considerable difficulty, inasmuch as the workable beds are found only under a cover of rock. The beds seem to have the form of thin lenses which wedge out gradually along the strike and dip.

IRON AND STEEL

By James Aston

The year 1914 will be remembered by the iron and steel industry as ıarking 12 months of most profound depression, accompanied by greatly ɔduced production of iron ore, coke, and iron and steel products. There as a continual decline in prices, and measured by financial results, the ear was one of the most distressing ever experienced by the iron trade.

In the first quarter of the year there was some recovery from the stag- ation of business which had marked the closing weeks of 1913, a number f idle blast furnaces resumed operations and the production of the steel ıills ran up to over 80 per cent. of their capacity. But the improve- ıent in demand was of short duration, being merely a replenishment of ;ocks. Then, with orders diminishing in number and size, the rate of roduction correspondingly fell until, in the late summer and fall months, ıe steel output was barely 35 per cent. of the capacity of the works. In ıct, for a brief period some of the largest steel manufacturers of the ɔuntry were only able to run at about 25 per cent.[1]

The important cause of the depression is attributed by the steel ıdustry to the opening up of our markets to foreign competition by the ew tariff act of October, 1913. Next in importance was the greatly iminished volume of buying by the railroads, whose traffic dwindled as he business of the country fell off, thus lessening their earnings until most tringent economy was necessary. The Mexican situation was a dis- urbing influence; and to cap the climax came the European war, which lislocated commerce and finance throughout the world.

An active selling campaign by foreign manufacturers resulted in sales ɔf much material along the Atlantic and Gulf coasts, and they almost :aptured the trade of the Pacific coast. The South, which had been en- ɔying exceptional prosperity for several years, was struck a stunning ɔlow in the complete stoppage of its exports of cotton, and by the general lepression and lack of outlet for their iron products.

One achievement of the year which may help to straighten out the ınancial difficulties, is the enactment of the new Federal banking act. t may be a material factor in bolstering up the present weak situation, nd in stabilizing conditions in the future, by loosening up immense apital through the expansion of the credit system and the establishment f commercial paper in a new and better light.

[1] *Iron Age*, Jan. 7, 1915.

Iron Ore

The United States Geological Survey reports a production of iron ore for 1914 of one-third less than that of the record year, 1913. The quantity mined is reported to have been 41,439,761 long tons, with shipments from mines 34,714,280 tons. Many mines were closed or running on half time during the latter part of the year, and owing to the present inactivity in the steel industry, and to the accumulation of considerable ore stocks by consumers, the iron mining companies are not expecting great activity in the early part of 1915.

Lake Superior District.—Ore shipments for the year fell off nearly 35 per cent., compared with the year before, and to a point over 15 per cent. below the average for the previous 10 years. Total shipments for all ranges were 32,729,726 tons, compared with 49,947,116 tons in 1913; a decline of 17,217,390 tons, or 34.47 per cent. Of this total, 32,021,897 tons was moved by water, and 707,829 tons represents the all-rail shipments.[1]

Total production of the Lake Superior district for a number of years past, together with shipments from the various ranges, are given in the two tables below:[2]

PRODUCTION OF IRON ORE IN LAKE SUPERIOR DISTRICT
(In tons of 2240 lb.)

Year.	Tonnage.	Year.	Tonnage.	Year.	Tonnage.	Year.	Tonnage.	Year.	Tonnage.
1855...	1,449	1880..	1,948,334	1902..	27,562,566	1907..	42,266,668	1912..	48,211,778
1860...	114,401	1885..	2,466,642	1903..	24,289,674	1908..	26,014,987	1913..	49,947,116
1865...	193,758	1890..	9,003,725	1904..	21,822,839	1909..	42,586,869	1914..	[3]33,229,726
1870...	859,507	1895..	10,429,037	1905..	34,353,456	1910..	43,442,397	.....	.....
1875...	881,166	1900..	19,059,393	1906..	38,522,239	1911..	32,793,120	.....	.....

SHIPMENTS OF IRON ORE FROM LAKE SUPERIOR DISTRICTS
(In tons of 2240 lb.)

Range.	1909.	1910.	1911.	1912.	1913.	1914.
Marquette.....	4,256,172	4,392,726	2,833,116	4,202,308	3,966,680	2,491,857
Menominee.....	4,875,385	4,237,738	2,911,174	4,711,440	4,965,604	3,221,358
Gogebic.....	4,088,057	4,315,314	2,603,318	4,996,498	4,531,558	3,568,482
Vermillion.....	1,108,215	1,203,177	1,088,930	1,844,981	1,566,600	1,016,993
Mesabi.....	28,176,281	29,201,760	22,093,532	32,047,409	34,038,643	21,465,967
Baraboo.....	82,759	91,682	115,629	104,031	145,010	105,765
Cuyuna.....	.....	.....	147,431	305,111	733,021	859,404
Total.....	42,586,869	43,442,397	31,793,130	48,211,778	49,947,116	32,729,726

Total shipments in 1914 were the lowest of any year since 1904, with the exception of 1908. Mesabi shipments suffered a decline of 12,572,676 tons, or 35 per cent., compared with 1913. Its percentage of total ship-

[1] *Iron Tr. Rev.*, Jan 7, Mar. 4, 1915.
[2] C. J. Stark, *Iron Tr. Rev.*, Feb. 12, 1914.
[3] Based on shipments plus 500,000 tons increase in stock piles.

ments from the district was 65.62 in 1914, against 68.15 in 1913, 66.46 in 1912, and 67.37 in 1911. Of the 1914 total, about 60 per cent. was shipped by the Oliver Iron Mining Co., the Steel Corporation's mining subsidiary. Shipments from mines leased from the state of Minnesota suffered severely, being only 804,722 tons in 1914, compared with 2,874,940 in 1913.

The Cuyuna range showed an increase of shipments for the year, because of development work which reached the production stage. Shipments were 859,404 tons. There was little in the line of new discovery during the year, and the limited exploration work was confined mostly to land adjacent to known deposits.[1]

During the year the Minnesota Tax Commission made a careful estimate of the tonnage and quality of the ore available on the Cuyuna range. The estimates are 70,857,865 tons of merchantable ore, and 13,907,949 tons of low-grade iron and manganiferous ore. No commercial manganese ore has been developed on the range; while there is a considerable quantity of manganese it is so mixed with the iron formation as to make it a manganiferous iron ore of little metallurgical value at present. The work of the commission has done much good in putting a damper on wildcat speculation schemes based upon fictitious estimates of promoters and speculators of 400 million to 500 million tons of ore reserves. And the report is particularly timely in view of the increased interest in the district because of supposedly enormous quantities of manganiferous material which were capable of exploitation on account of cutting off of foreign supplies.

The Vermillion range had a relatively successful season, reduction in shipments being from 1,566,600 tons in 1913 to 1,016,993 in 1914, or 35.1 per cent. The Oliver Iron Mining Co. produced the bulk of the ore.

The older ranges, Marquette and Menominee, showed the most striking decline in shipments, and with the exception of 1908, those of the latter range were the lowest of any year since 1898, and of the former, since 1895. Marquette shipments decreased by 1,474,823 tons, or 35.9 per cent. The Cleveland-Cliffs mine headed the list of shippers, as usual. Menominee shipments declined by 1,744,346 tons, or 34.7 per cent.

The Gogebic range was the second largest shipper in 1914, with 3,568,482 tons, or 10.9 per cent. of the total for the Lake district. The reduction from 1913 was 963,076 tons, or 21.2 per cent.

The following new mines shipped in 1914:

Mesabi.—Deacon, Duncan, Higgins No. 1, Leonidas, Prindle, Shiras, and Wanless, of the Oliver Iron Mining Co.; Harrison, and Quinn, of

[1] *Eng. Min. Jour.*, Jan. 9, 1915.

the Harrison Iron Mining Co.; Hill Annex, of the Arthur Iron Mining Co.: total, 10.

Gogebic.—Keweenaw, of the Newport Mining Co.; total, 1.

Menominee.—Carpenter, of Hollister Mining Co.; Ernst, of Florence Iron Co.; Judson, of Judson Mining Co.; Rogers, of Munro Mining Co.; total, 4.

Cuyuna.—Rowe, of Pittsburgh Steel Co.; total, 1.

The total of new shippers in 1914 was 16, compared with 20 in 1913, 13 in 1912, 12 in 1911, and 16 in 1910. Shipments from new mines in 1914 totaled 677,182 tons.

Two mines which have been idle for years resumed shipments in 1914. They are the Holland, on the Mesabi, idle since 1907; and the Hilltop, on the Menominee, with last production in 1906.

During 1914 there were shipments from 196 mines, compared with 223 in 1913, 194 in 1912, 184 in 1911, 196 in 1910, and 172 in 1909. The distribution was—Mesabi 94, Menominee 41, Marquette 25, Gogebic 21, Cuyuna 7, Vermillion 6, Mayville and Baraboo 2.

Of the mines which shipped in 1913, 54 forwarded no ore in 1914, distributed as follows: Mesabi 31, Menominee 11, Marquette 6, Gogebic 3, Vermillion 1, Cuyuna 2.

For the third successive year, the independent ore-mining companies shipped more than half of the tonnage, the exact ratio being 50.99 per cent. The Mahoning mine with 1,212,378 tons, and the Susquehanna mine of Rogers, Brown & Co., with 906,913 tons, both Marquette properties, were the big producers of the independents.

The shipments of the Oliver Iron Mining Co. for several years are given below:

	Gross Tons.	Per Cent. of Total.
1906	20,414,811	53.00
1907	22,710,898	56.00
1908	14,123,957	56.00
1909	21,397,866	50.36
1910	21,661,143	49.86
1911	17,282,449	52.70
1912	23,845,363	49.46
1913	24,502,244	49.06
1914	16,039,654	49.01

The big shippers of the Corporation mines were the Leonard with 2,686,285 tons; Sauntry-Alpena, 1,131,255; and Canisteo, 1,051,895 tons. The first named, one of the Hill group, shipped out over double the tonnage of 1913; while the great Hull-Rust pit produced only 458,468 tons, as contrasted with 3,457,608 tons in 1913.

Of the 16,039,654 tons shipped in 1914, 6,013,758 tons was under

the "Hill lease" with the Great Northern Ore Co. This was slightly over the minimum movement of 6,000,000 tons provided under the terms of the lease. Announcement of the termination of this lease was made by the directors of the Steel Corporation in October, 1911, and the shipments for 1914 mark the last under the contract. Heavy production from these holdings in later years more than made up the deficiencies in shipment in the earlier period of the lease, and the Corporation terminated it with a surplus to its credit over the graded minimum tonnage stipulated in the contract.

The Oliver Iron Mining Co. has for years been developing new properties to replace those relinquished by the cancellation of the Hill lease. This company is therefore in good position, both with respect to ore in condition for immediate mining and in reserves.

During the year the Oliver company developed nine new mines on the Mesabi range, all underground properties, containing several million tons of ore. Seven of these made their initial shipments in 1914. These underground properties are provided with the most permanent equipment, such as concrete shafts, steel head frames, concrete houses, etc. In addition to the development of the above mines, the Oliver company is draining Carson Lake, west of Hibbing. The water is being pumped out and the lake bed is being filled with stripping from near-by mines. About 4,000,000 tons of merchantable ore will be reclaimed on the above company's portion of the lake property. Stripping operations of the Oliver company have been reduced to a minimum during the winter.[1]

Washing of Mesabi ores has been practised to a considerable degree during the year, the Oliver Iron Mining Co. shipping 1,574,835 tons of concentrate from its Trout Lake plant, and the International Harvester Co., 229,608 tons from its mill near Nashwauk. Experimental washing plants have been erected at other mines in the Lake Superior district, and larger installations are being considered. Drying of ores has been carried out at the Brunt mine near Mountain Iron, about 130,000 tons of ore being treated.

The Lake Superior Iron Ore Association has compiled the average analyses of Bessemer and non-Bessemer ores, and their relative proportions in total shipments, with the exception of low-grade siliceous and manganiferous ores, and small tonnages of other ores not included.[2] No important changes as to analyses are noted for 1914, as compared with 1913, but there has been a very marked decline in the percentage of Bessemer, as compared with non-Bessemer since 1902. For the Mesabi, the percentage of Bessemer was 38.7 in 1914, 41.5 in 1913, and 80.5 in 1902; for the old ranges, 33.5 in 1914, 36.3 in 1913, and 47.5 in 1902;

[1] *Iron Tr. Rev.*, Jan. 7, 1915.
[2] *Iron Tr. Rev.*, May 13, 1915.

while for the entire Lake Superior district, the Bessemer ores were 37.2 per cent. of the output in 1914, compared with 40 per cent. in 1913, and 65 per cent. in 1902. The phosphorus content of Bessemer ores has not changed to a marked degree in recent years, although there has been a material increase over the total period since 1902.

The average iron content (natural) of all Lake Superior shipments for 1914, was 51.611 per cent., as compared with 51.631 for 1913 output. The decrease, while slight, drops the average to the lowest point recorded in the past dozen years. On the old ranges the average natural iron content increased in 1914 to 53.468 per cent., compared with 53.342 per cent. in 1913. On the Mesabi, the average natural iron content decreased in 1914 to 50.748, compared with 50.970 in 1913.

In the old ranges the average phosphorus of Bessemer ores was 0.03897 per cent. in 1914, compared with 0.03936 per cent. in 1913. For the Mesabi Bessemers, the figures are 0.04512 in 1914, against 0.04427 per cent. in 1913. For all ranges, the phosphorus content of Bessemer ores was 0.04335 per cent. in 1914, compared with 0.04303 per cent. in 1913. The average silica content of all Bessemer ore shipments in 1914 was 7.7192 per cent., compared with 6.8092 per cent. in 1909. Average moisture was 10.6625 per cent. in 1914, compared with 10.7906 per cent. in 1913, and 10.0862 per cent. in 1912.

SELLING PRICE OF IRON ORE AND PRICE OF PIG IRON AT DATE OF BUYING MOVEMENT 1890–1915

Season.	Date Buying Movement.	Season Iron Ore Prices.				Iron Prices—Valley.	
		Old Range Bessemer.	Mesabi Bessemer.	Old Range Non-Bessemer.	Mesabi Non-Bessemer.	Bessemer.	Foundry Iron No. 2.
1890.....	Dec. 15, 1889	$5.50	No sale	$5.25	No sale	$22.15	$18.15
1891.....	June 1, 1891	4.50	No sale	4.25	No sale	15.15	15.00
1892.....	Jan. 31, 1892	4.50	No sale	3.65	No sale	15.00	13.65
1893.....	Mar. 15, 1893	3.85	$3.00	3.20	No sale	12.65	12.15
1894.....	Mar. 1, 1894	2.75	2.35	2.50	No sale	9.65	9.65
1895.....	April 1, 1895	2.90	2.19	2.25	$1.90	9.40	9.40
1896.....	May 1, 1896	4.00	3.50	2.70	2.25	12.40	11.15
1897.....	May 20, 1897	2.60	2.25	2.15	1.90	8.35	8.40
1898.....	Mar. 20, 1898	2.75	2.25	1.85	1.75	9.55	9.80
1899.....	Feb. 1, 1899	3.00	2.40	2.15	2.00	10.30	9.75
1900.....	Dec. 15, 1899	5.50	4.50	4.25	4.00	24.15	22.15
1901.....	April 15, 1901	4.25	3.25	3.00	2.75	16.15	14.40
1902.....	Feb. 1, 1902	4.25	3.25	3.25	2.75	15.90	15.90
1903.....	Mar. 20, 1903	4.50	4.00	3.60	3.20	21.50	21.65
1904.....	April 15, 1904	3.25	3.00	2.75	2.50	13.35	13.15
1905.....	Feb. 1, 1905	3.75	3.50	3.20	3.00	15.50	16.00
1906.....	Dec. 5, 1905	4.25	4.00	3.70	3.50	17.25	17.25
1907.....	Nov. 5, 1906	5.00	4.75	4.20	4.00	21.50	21.50
1908.....	June 15, 1908	4.50	4.25	3.70	3.50	16.00	15.00
1909.....	May 10, 1909	4.50	4.25	3.70	3.50	14.75	14.25
1910.....	Dec. 24, 1909	5.00	4.75	4.20	4.00	19.00	17.25
1911.....	Apr. 21, 1911	4.50	4.25	3.70	3.50	15.00	13.75
1912.....	Mar. 20, 1912	3.75	3.50	3.00	2.85	14.25	13.25
1913.....	Nov. 19, 1912	4.40	4.15	3.60	3.40	17.25	17.50
1914.....	May 1, 1914	3.75	3.50	3.00	2.85	14.00	13.25
1915.....	Apr. 19, 1915	3.75	3.50	3.00	2.85	13.60	13.75

Prices for Lake Superior ores were lower in 1914 than in the year previous. The selling prices at the date of the buying movement for the period from 1890 to 1915 is given above, for the several grades of ore. Also for the benefit of comparison, the pig iron prices at corresponding periods are given.[1]

New York and New Jersey.—Reduced activities at eastern blast furnaces in 1914 had their result upon the mining and shipping operations in these districts. The Port Henry region, centering at Mineville, produced about 650,000 tons of crude ore, against about 1,000,000 tons in 1913. Furnace demand for the crude and high phosphorus ores was small, and this necessitated light operations on the part of some of the mines not supplied with facilities for concentration. For high-grade ores and concentrates there was fair demand. Prices for 1914 averaged 6½ to 7¾ cts. per unit of iron, delivered in eastern Pennsylvania. The small demand for Bessemer concentrates resulted in the Barton Hill mine and mill of Witherbee, Sherman & Co. being idle. The Cheever mine was active for part of the year.[2]

New construction and development was limited because of the poor market for ore. Witherbee, Sherman & Co. are building a large modern mill to replace the two smaller ones destroyed by fire. The capacity will be 1500 tons of crude ore daily. Other projects of the above company, such as modern ore docks at Port Henry and blast furnaces at New York tidewater, are held in abeyance because of the condition of the iron and financial markets.

Exploration work has been conducted by the Essex and Clinton Ore Co. in the Bullwagge Mountain district on the west shore of Lake Champlain. The ores are characteristic black magnetite and another variety resembling the titaniferous Lake Sanford ores. The former shows from 44 to 59 per cent. iron and is free from sulphur, phosphorus, and titanium. Commercial utilization is expected with the opening of the barge canal to Lake Champlain. There has been no further exploitation of the titaniferous deposits of the MacIntyre Iron Co. in the Lake Sanford district other than the trial smelting tests noted in the section on Titanium.

Among the local New Jersey and New York mines, activities as a rule were very restricted, although there was a fair demand for the higher grades of product. While in certain sections there was new construction of mine and mill plants, and development work, in general plans for improvement and modernizing were not actively advanced during the past year. The Thomas Iron Co. added considerably to its resources by the important new development at its Richard mine at

[1] *Iron Tr. Rev.*, Apr. 22, 1915.
[2] C. J. Stark, *Iron Tr. Rev.*, Jan. 14, 1915.

Wharton, N. J. A new ore-body of magnetite ore, rich in iron and with considerable vanadium and some titanium, was opened up.

Alabama.—There have been few mining developments for the past year in the Birmingham district. Important improvements were made at the Woodward Iron Co., mainly in the blast-furnace plant. There was also some remodeling at the Tennessee Coal, Iron & Railroad Co. Practically all of the 15 Tennessee company mines were in operation for the first half of the year, but production was reduced considerably in the last half.

The canalization of the Black Warrior River, now in partial stage of completion, is looked forward to by the South as a factor in putting the Birmingham district in a position to ship to the Atlantic seaboard, and via the Panama Canal to the Pacific coast. While there may be some possibility of marketing ore and coal, and certainly there should be considerable outlet for the pig iron, it is considered that the really sound basis is to use the pig iron to make steel and sell abroad the surplus of finished products.

Imports.[1]—Imports of foreign ore to the United States in 1914 aggregated 1,351,368 tons, or 1,243,402 tons less than in 1913. This makes the smallest movement since 1908, when 776,989 tons was brought in, and about equaled the figure for 1907. Shipments of trans-Atlantic ore in 1914 aggregated about 410,000 tons, compared with approximately 500,000 in 1913. The only trans-Atlantic ore to show an increase last year was the El Capitan from North Africa. About 46,000 tons was received, compared with 12,950 tons in 1913, the first year of importation. A considerable tonnage of the African ore has been contracted for, and should there be any considerable revival in the iron industry during the coming year, a large increase in shipments is expected, and this ore is likely to become a big factor in supplies for eastern furnaces.

Cuban ore mining and shipments to the United States in 1914 were the smallest since 1908. The shipments aggregated 815,017 tons, compared with 1,582,431 in 1913. Of last year's shipments, 560,000 tons came from the Daiquiri or south coast district, and 255,000 tons from the Mayari or north coast region. Corresponding figures for 1913 were 1,080,728 and 491,713. Practically all of the above tonnage went to the Bethlehem, Maryland and Pennsylvania Steel Companies, about 70,000 tons being distributed to merchant furnaces. Sales were on the basis of 7 cts. per unit at tidewater for the ordinary Bessemers, and about 8 cts. for low phosphorus grades.

Importations of Swedish ore were 280,887 tons in 1914, which went exclusively to the Bethlehem Steel Co. and the Reading Iron Co. under

[1] *Iron Tr. Rev.*, Jan. 14, 1915.

long term contracts. The year's deliveries, however, were considerably less than contract specifications.

Spanish ore shipments to eastern furnaces in 1914 were 66,982 tons, the smallest for a number of years. There has been in recent years a decided falling off in interest in these ores, and their movement to this country reached a maximum tonnage of 439,868 in 1910.

Imports from Newfoundland suffered a marked decline in 1914, being 38,515 tons, as compared with 213,468 in 1913. From Canada one cargo of 4350 tons was received in the East from the Bathurst, New Brunswick, mines. In addition, 208,387 tons of ore was received from Canadian mines in the Lake Superior district, for inland furnaces, compared with 164,722 tons in 1913.

Venezuelan imports declined to a negligible quantity, 2400 tons in 1914, compared with 59,000 tons in 1913.

The past year marked the beginning of ore receipts in this country from Chile, and the extensive development work of the Bethlehem Steel Co. presages a large annual tonnage from this field in the future. During the year six cargoes of ore aggregating 42,000 tons were shipped to Philadelphia, and three cargoes totaling 21,000 tons to Europe. The latter consignments were on contracts entered into before the acquisition of the holdings by the Bethlehem Steel Co. Three of the cargoes to Philadelphia came through the Panama Canal.

Exports.—Exports of iron ore from the United States in 1914 were 551,618 tons, mainly to Canada. For 1913 the total was 1,042,051 tons.

Iron and Steel Markets

The year 1914 has been one of decided weakness in prices, but owing to the low level at the close of 1913, the prices at the close of 1914 did not show much change. An interesting fact is that at the close of the year southern iron dropped below $10 for the first time since 1904, with the exception of a short period in 1911. When one takes into consideration the increased cost of production as compared with earlier years, it is evident that the quotations at the close of 1914 were extremely low.[1]

With the ending of the year 1913 it was believed that bottom had been reached in the downward sweep in prices and volume of business, and that recovery must be near at hand. The spurt of optimism was, however, smothered by actual condition of business. The buying public was not ready to take manufactured products; railroads refused to buy; and agricultural implement makers had overstocked the previous year. A downward movement began in March that continued steadily until

[1] *Iron Tr. Rev.*, Jan. 7, 1915.

August, when conditions seemed ripe for a resumption of activity and a better condition of the market in general. Just as things appeared propitious for an upward movement, there came the declaration of war in Europe, and buying ceased with the uncertainty in the business world. Prices held nominally in the face of almost entire absence of buying until September and October, when they began to sag, and this condition continued practically to the close of the year, with quotations at the end at the lowest mark for 2 years.

Below are given the average prices of pig iron at Chicago, for several years past and by months for 1914:[1]

AVERAGE CHICAGO PRICES OF PIG IRON, 1914

	Northern Coke No. 2.	Lake Superior Charcoal.	Southern Coke No. 2
January	$13.80	$15.25	$14.85
February	14.00	15.25	14.85
March	14.25	15.25	15.10
April	14.25	15.45	14.85
May	14.06	15.75	14.85
June	13.69	15.75	14.72
July	13.75	15.75	14.60
August	13.69	15.75	14.35
September	13.31	15.75	14.35
October	12.94	15.75	14.00
November	12.56	15.75	14.00
December	12.90	15.75	13.60
Average for year	13.60	15.60	14.46
Average for 1913	$15.95	$16.50	$16.12
Average for 1912	15.32	16.77	16.11
Average for 1911	14.87	16.96	14.80
Average for 1910	17.10	18.67	16.30
Average for 1909	17.49	19.50	17.30
Average for 1908	17.57	20.24	16.76
Average for 1907	24.50	26.56	24.47
Average for 1906	20.43	20.72	19.44

Extreme depression existed in the pig-iron market, more so even than in the steel situation. The price of foundry iron was forced down from a maximum of $14.25 in March to the basis of $12.50 for Northern No. 2 in November.[2] In basic pig iron, competition in the open market by the steel company stacks made the situation particularly acute for merchant furnaces making this grade. And at the prices which prevailed for Northern iron, pig iron from the South was able to compete only in the most favorably located sections of the Chicago district. Although a reduction of freight from southern territory to Chicago went into effect in the last quarter of the year, it helped in no wise, since northern producers immediately neutralized the advantage by a cut in their own price. Also, the ambiguity in the statement of the new rate practically made it ineffective in districts served by certain of the railroads.

Consumption of Southern iron in the Chicago district for the year

[1] *Iron Age*, Jan. 7, 1915.
[2] *Iron Age*, Jan. 7, 1915.

was only about 50 per cent. of the normal tonnage. Prices for the year were nominally above those quoted for like Northern grades, and were fairly maintained throughout the year, in spite of the adverse situation. Prices varied from a maximum of $15.10 in March to $13.60 as a minimum in December. The average price for the year for Southern iron at Chicago was $14.46.

Prices of Lake Superior charcoal iron were well maintained throughout the year. While there was a better comparative movement of charcoal than coke-iron tonnage, compared on a producing capacity basis, the stability in the charcoal pig-iron market was largely by reason of the limited capacity of furnaces in blast.

In the Pittsburgh district the pig-iron market throughout the year was much depressed. Prices declined from a high level, reached in March, to the low mark prevailing at the end of the year. Average monthly prices for 1914 are given in the following table:

AVERAGE MONTHLY PIG-IRON PRICES, F.O.B., VALLEY FURNACE, 1914

Month.	Bessemer.	Basic.	No. 2 Foundry.	Gray Forge.
January	$14.10	$12.50	$12.85	$12.75
February	14.19	13.19	13.19	12.75
March	14.19	13.00	13.25	12.75
April	14.00	13.00	13.25	12.75
May	14.00	13.00	13.00	12.75
June	14.00	13.00	13.00	12.75
July	14.00	13.00	13.00	12.75
August	14.00	13.00	13.00	12.75
September	14.00	12.94	13.00	12.75
October	13.95	12.80	12.90	12.68
November	13.64	12.47	12.75	12.50
December	13.75	12.50	12.75	12.45

The freight rate from valley furnaces to Pittsburgh was 90 cts. per ton up to Nov. 1, and 95 cts. for November and December.

The year opened with but a moderate demand for steel. Bessemer and open-hearth billets were quoted at $20, and sheet bars at $21, Pittsburgh. There was not much change in prices throughout the year, except slight advances in February and June due to better demand. From July, and particularly after the European war started, demand for billets and sheet bars steadily declined, and prices continued low through the last half. At the end of the year Bessemer and open-hearth billets were selling at about $19, and sheet bars at $20, f.o.b. Pittsburgh mill.[1]

The steel-rail trade throughout the year was probably the worst in its history. At no time were the principal mills operating at over 50 per cent. of capacity, and in the last half of the year no rails whatever were being made at many of the mills. The price of standard Bessemer rails was maintained steadily throughout the year at $28 per ton, and of open hearth at $30, f.o.b. Pittsburgh.

[1] *Iron Age*, Jan. 7, 1915.

Demand for structural shapes for the first half of 1914 was fairly heavy, but in the second half was so dull that prices declined sharply. Operations of fabricating shops in the last half-year were not over 40 to 50 per cent. of normal. The year opened with beams and channels, up to 15-in., ruling at 1.20 cts. per lb., Pittsburgh, which was the high mark reached during the year. From time to time the market declined and several attempts to hold it to 1.20 cts. failed because of the light demand. At the end of the year heavy beams and channels were quoted as low as 1.05 cts. for prompt shipment.

The demand for steel plates was much less than in 1913. In the first half of the year considerable car building in progress kept the plate mills operating at 60 to 75 per cent. of capacity. In the last half, and particularly after the European war started, car building practically stopped, and plate mill operations dropped to one-fourth or one-third of capacity. The year opened with plates selling at 1.20 cts., Pittsburgh, but at no time did the price rise higher than this, and for most of the year was lower. In the last 4 or 5 months plates sold at 1.05 to 1.10 cts., or even slightly. less in a few instances.[1]

Tubular goods in the first half-year enjoyed a reasonably good demand, but trade in the last half dropped off, in common with other products. For the closing months of the year mill operations were not much over one-third of capacity. Prices on wrought-iron pipe were well maintained throughout the year, but a cut of $1 in steel pipe was made in November.

Sheet and tinplate mills had a rather unsatisfactory year in 1914, with low prices and relatively light tonnage. Tinplate output somewhat exceeded that of 1913, but sheet tonnage for 1914 fell considerably below that of the preceding year. Competitive conditions resulted in unsatisfactory prices, but not necessarily ruinous ones, since there was the accompanying decline in the price of raw materials. Average prices for the year were 1.89 cts. per lb. on No. 28 black sheets, compared with 2.21 cts. in 1913; on No. 28 galvanized sheets, 2.87 cts., compared with 3.28; and on tinplate, 3.35 cts. in 1914, compared with 3.56 cts. in 1913. From 1913 to 1914, the average drop in prices was $6.40 a ton on black sheets, $8.20 on galvanized sheets, and $4.20 on tinplate.

There was no active demand for iron and steel scrap during the year. The high mark in prices was reached in the first 2 months. There was a sharp decline in March, but little fluctuation until July, although the condition of steel plant operations made demand dull. After the start of the European war, scrap declined still further. The low mark was reached in November, at which time heavy melting steel scrap sold at $10

[1] *Iron Age*, Jan. 7, 1915.

MONTHLY MINIMUM PRICES AT PITTSBURGH IN 1914

	Jan.	Feb.	Mar.	Apr.	May.	June.	July.	Aug.	Sept.	Oct.	Nov.	Dec.
Ferrosilicon	$73.00	$73.00	$73.00	$73.00	$73.00	$73.00	$73.00	$73.00	$73.00	$73.00	$73.00	$73.00
Bessemer billets	20.00	21.00	21.00	20.80	20.00	19.75	19.30	20.00	21.00	20.60	19.00	18.50
Open-hearth billets	20.00	20.75	21.00	20.80	20.00	19.75	19.30	20.00	21.00	20.60	19.00	18.50
Bessemer sheet bars	21.00	22.00	22.00	21.60	21.00	20.75	20.20	21.00	22.00	21.60	19.62	19.00
Open-hearth sheet bars	20.60	21.75	22.00	21.60	21.00	20.75	20.20	21.00	22.00	21.60	19.62	19.00
Steel rails	1.25c.	1.25c.	1.25c.	1.25c.	1.25c.	1.25c.	1.25c.	1.25c.	1.25c.	1.25c.	1.25c.	1.25c.
Beams	1.20c.	1.20c.	1.20c.	1.18c.	1.15c.	1.11c.	1.11c.	1.17c.	1.20c.	1.17c.	1.11c.	1.05c.
Plates	1.15c.	1.20c.	1.20c.	1.15c.	1.12c.	1.10c.	1.11c.	1.16c.	1.18c.	1.14c.	1.09c.	1.05c.
Steel bars	1.20c.	1.20c.	1.20c.	1.15c.	1.15c.	1.11c.	1.11c.	1.17c.	1.20c.	1.17c.	1.10c.	1.05c.
Iron bars	1.31c.	1.30c.	1.30c.	1.30c.	1.30c.	1.27c.	1.23c.	1.20c.	1.20c.	1.20c.	1.20c.	1.15c.
Tinplate	$3.40	$3.40	$3.40	$3.40	$3.38	$3.30	$3.27	$3.46	$3.55	$3.36	$3.17	$3.20
No. 28 gauge black sheets	1.86c.	1.94c.	1.95c.	1.92c.	1.87c.	1.82c.	1.80c.	1.88c.	1.95c.	1.93c.	1.89c.	1.80c.
No. 28 gauge galvanized sheets	2.86c.	2.94c.	2.95c.	2.92c.	2.80c.	2.77c.	2.75c.	2.85c.	2.95c.	2.93c.	2.86c.	2.80c.
No. 10 blue annealed sheets	1.37c.	1.40c.	1.40c.	1.40c.	1.37c.	1.35c.	1.35	1.37c.	1.40c.	1.40c.	1.39c.	1.35c.
Wire rods	$25.50	$25.88	$26.00	$26.00	$26.00	$25.50	$24.80	$24.50	$25.62	$26.00	$25.75	$25.00
Wire nails	1.55	1.59	1.60	1.60	1.57	1.50	1.51	1.55	1.55	1.59	1.59	1.50
Plain wire	1.35	1.39	1.40	1.40	1.37	1.30	1.31	1.35	1.35	1.39	1.39	1.30
Hoops	1.40c.	1.30c.	1.30c.	1.26c.	1.25c.	1.25c.	1.25c.	1.25c.	1.25c.	1.25.c	1.25c.	1.25c.
Heavy melting steel	$11.05	$12.37	$12.25	$12.00	$12.00	$12.00	$11.55	$11.50	$11.44	$10.75	$10.06	$10.35
Structural rivets	1.62c.	1.60c.	1.60c.	1.60c.	1.60c.	1.56c.	1.50c.	1.50c.	1.55c.	1.48c.	1.45c.	1.45c.

or under, bundled sheet scrap $8, re-rolling rails at $11.50 to $11.75, borings at $7.50 to $7.75. Some recovery in prices resulted in December, with improvement in demand.

Pittsburgh prices on various classes of product are given in the table in the accompanying page.

Pig Iron

The production of pig iron in 1914 totaled 23,332,224 gross tons, against 30,966,152 tons in 1913, a loss for the year of 7,638,928 tons, or 24.6 per cent. This is the smallest yearly tonnage for 9 years, except for the lean year in 1908, when the production was 15,936,018 tons. The pig-iron production of the United States for the past 100 years is shown in the following table:[1]

[1] *Amer. Iron & Steel Inst., Bull.* 1, 1915.

PIG-IRON PRODUCTION FOR 100 YEARS

1820.....	20,000	1859.....	750,650	1878.....	2,301,215	1897.....	9,652,680
1828.....	130,000	1860.....	821,223	1879.....	2,741,853	1898.....	11,773,934
1829.....	142,000	1861.....	653,164	1880.....	3,835,191	1899.....	13,620,703
1830.....	165,000	1862.....	703,270	1881.....	4,144,254	1900.....	13,789,242
1831.....	191,000	1863.....	846,075	1882.....	4,623,323	1901.....	15,878,354
1832.....	200,000	1864.....	1,014,282	1883.....	4,595,510	1902.....	17,821,307
1840.....	286,903	1865.....	831,770	1884.....	4,097,868	1903.....	18,009,252
1842.....	215,000	1866.....	1,205,663	1885.....	4,044,526	1904.....	16,497,033
1846.....	765,000	1867.....	1,305,023	1886.....	5,683,329	1905.....	22,992,380
1847.....	800,000	1868.....	1,431,250	1887.....	6,417,148	1906.....	25,307,191
1848.....	800,000	1869.....	1,711,287	1888.....	6,489,738	1907.....	25,781,361
1849.....	650,000	1870.....	1,665,179	1889.....	7,603,642	1908.....	15,936,018
1850.....	563,755	1871.....	1,706,793	1890.....	9,202,703	1909.....	25,795,471
1852.....	500,000	1872.....	2,548,713	1891.....	8,279,870	1910.....	27,303,567
1854.....	657,337	1873.....	2,560,963	1892.....	9,157,000	1911.....	23,649,547
1855.....	700,159	1874.....	2,401,262	1893.....	7,124,502	1912.....	29,726,937
1856.....	788,515	1875.....	2,023,733	1894.....	6,657,388	1913.....	30,966,301
1857.....	712,640	1876.....	1,868,961	1895.....	9,446,308	1914	23,332,244
1858.....	629,548	1877.....	2,066,594	1896.....	8,623,127	.....	.....

Below is given the production of pig iron by half-yearly periods from 1909 to 1914, in gross tons. Included in the totals for recent years is the limited yearly tonnage of ferrophosphorus, ferrotitanium, ferrovanadium, and other ferro-alloys:

Periods.	1909.	1910.	1911.	1912.	1913.	1914.
First half.....	11,022,346	14,978,738	11,666,996	14,072,274	16,488,602	12,536,094
Second half.....	14,773,125	12,324,829	11,982,551	15,654,663	14,476,699	10,796,150
Total.....	25,795,471	27,303,567	23,649,547	29,726,937	30,966,301	23,332,244

The falling off in production, started in the last half of 1913, continued in the first half of 1914, the output for the latter period being 12,536,094 tons. The decline lasted throughout 1914, and production for the second half fell off to 10,796,156 tons, an amount less than for any half-year since 1908.

In no state or district of the country was there an increase of production of pig iron in 1914, as compared with 1913. The decrease ranged from 11.2 per cent. for Alabama to 48.52 per cent. for Connecticut and Massachusetts. In Pennsylvania the decrease was 3,221,567 tons, or 24.87 per cent.; in Ohio, 1,846,099 tons, or 25.89 per cent.; and in Illinois, 1,080,381 tons, or 36.90 per cent. During the year Pennsylvania produced 41.72 per cent. of the country's output, Ohio 22.64, Illinois 7.92, Alabama 7.83, New York and New Jersey 6.69, and Indiana and Michigan 6.67 per cent. of the total. Production by states is as follows:

PRODUCTION OF PIG IRON BY STATES
(In tons of 2240 lb.)

States.	1908.	1909.	1910.	1911.	1912.	1913.	1914.
ssachusetts							
Connecticut..	13,794	18,388	16,582	9,649	17,366	12,810	6,594
r York.	1,019,425	1,733,675	1,938,407	1,562,756	1,939,231	2,187,620	1,559,864
r Jersey.	225,372	294,474	264,781	40,663	36,876		
nsylvania ...	6,987,191	10,918,824	11,272,323	9,807,073	12,552,131	12,954,940	9,733,369
yland.....	183,502	286,856	326,214	255,816	219,546	289,959	195,594
ginia.....	320,458	391,134	444,976	293,642	256,167	341,815	271,228
bama.....	1,397,014	1,763,617	1,939,147	1,712,211	1,862,681	2,057,911	1,826,929
Car., Geo., exas.	24,345	26,072	14,725	1,200	*Nil.*	.....	.....
st Virginia. ..	65,551	228,282	174,661	291,472	274,360	315,731	(b)236,393
ntucky.....	45,096	86,371	100,509	95,202	68,760		
nessee.....	290,826	333,845	397,569	324,648	338,238	280,541	216,738
o.....	2,861,325	5,551,545	5,752,112	5,310,506	6,802,493	7,129,525	5,283,426
nois	1,691,944	2,467,155	2,675,646	2,108,002	2,887,359	(a)2,927,977	1,847,451
bigan.....	(a)348,096	(a)964,289	(a)1,250,103	1,163,932	(a)1,770,628	1,775,883	(a)1,557,355
sconsin, Minn.	148,938	348,177	307,200	276,807	303,370	367,326	329,526
of Miss. River	313,071	382,767	428,612	395,968	397,731	324,263	267,777
otal.....	15,926,948	25,795,471	27,303,567	23,649,547	29,726,937	30,966,301	23,332,244

(a) Includes Indiana. (b) Includes Mississippi.

Production of pig iron from 1908 to 1913, according to fuel used, is ven below:

PIG-IRON PRODUCTION ACCORDING TO THE FUEL USED
(In tons of 2240 lb.)

Fuel Used.	1908.	1909.	1910.	1911.	1912.	1913.	1914.
ke(a).....	15,331,863	24,721,037	26,257,978	23,141,296	29,132,733	30,348,973	22,976,856
thracite & coke	318,741	682,383	628,579	212,548	236,467	254,901	91,464
thracite alone...	36,268	16,048	20,503	17,027	10,712	22,446	
arcoal.....	(b)249,146	(b)376,003	396,507	278,676	347,025	339,981	263,924
arcoal & coke..							
Total.....	15,936,018	25,795,471	27,303,567	23,649,547	29,726,937	30,966,301	23,332,244

(a) Under coke furnaces are included the very few which use raw bituminous coal. It may be umed that 99 per cent. of this class of iron was made with coke. (b) Includes a small quantity de by the electric furnace.

Below is listed the production of pig iron according to character of oduct. Low phosphorus pig iron, that is, iron running under 0.04 r cent. phosphorus, is included in Bessemer pig iron; the latter is iron ntaining from 0.04 to 0.10 P. The figures for the last 2 years include der basic iron a small quantity of charcoal iron of basic grade. Nearly l of the charcoal iron is classed as foundry iron; pig iron of high silicon included in the foundry group, while under "all other grades" are in-ded white and mottled iron, direct castings, and miscellaneous ferro-oys.

PRODUCTION OF PIG IRON BY GRADES, 1905–1914

Years.	Basic.	Bessemer.	Foundry.	Malleable.	Forge.	All Other.	Total, Gross Tons.
1905	4,105,179	12,407,116	4,758,038	635,236	727,817	358,994	22,992,380
1906	5,018,674	13,840,518	4,773,011	699,701	597,420	377,867	25,307,191
1907	5,375,219	13,231,620	5,151,209	920,290	683,167	419,856	25,781,361
1908	4,010,144	7,216,976	3,637,622	414,957	457,164	199,155	15,936,018
1909	8,250,225	10,557,370	5,322,415	658,048	725,624	281,789	25,795,471
1910	9,084,608	11,245,642	5,260,447	843,123	564,157	305,590	27,303,567
1911	8,520,020	9,409,303	4,468,940	612,533	408,841	229,910	23,649,547
1912	11,417,886	11,664,015	5,073,873	825,643	469,183	276,337	29,726,937
1913	12,536,693	11,590,113	5,220,343	993,736	324,407	300,860	30,966,152
1914	9,670,687	7,859,127	4,533,254	671,771	361,651	235,754	23,332,244

PRODUCTION OF PIG IRON BY GRADES, 1913–1914, SHOWING INCREASE OR DECREASE BY GRADES

Grades.	1914.	Per cent.	1913.	Per cent.	Decrease.	Per cent.
Basic	9,670,687	41.45	12,536,693	40.48	2,866,006	22.86
Bessemer	7,859,127	33.68	11,590,113	37.43	3,730,986	32.19
Foundry	4,533,254	19.43	5,220,343	16.86	687,089	13.16
Malleable	671,771	2.88	993,736	3.21	321,965	32.40
Forge	361,651	1.55	324,407	1.05	[1]37,244	[1]11.48
Spiegeleisen	79,935	0.34	110,338	0.36	30,403	27.55
Ferromanganese	106,083	0.46	119,495	0.38	13,412	11.22
All other	49,736	0.21	71,027	0.23	21,291	29.98
Total	23,332,244	100.00	30,966,152	100.00	7,633,908	24.65

[1] Increase.

During the year there was a relative increase in the percentage of iron of basic grade, as compared with 1913, showing the continual ascendency of the open-hearth process for the manufacture of steel in this country. Compared with 1913, there was a decline in tonnage in all grades of pig iron manufactured, except for forge iron, which shows a little gain.

Of the 23,332,244 tons of pig iron made in 1914, 7,362,980 tons, or 31.5 per cent., was for sale. In 1913 the proportion was 31.1 per cent. Of the 1914 total for sale, 4,393,089 tons was of foundry grade, and 671,771 of malleable. Basic iron sold aggregated 1,479,721 tons.

The forms in which the pig iron made in recent years was cast or delivered are given below.

METHODS BY WHICH ALL PIG IRON WAS CAST OR DELIVERED

States.	Molten Condition.	Sand Cast.	Machine Cast.	Chill Cast.	Direct Castings.	Total, Gross Tons.
Mass., Conn.	.....	6,594	.....	.....	.....	6,594
N. Y., N. J., Md.	557,501	777,563	293,541	126,244	609	1,755,458
Pennsylvania	5,730,713	1,115,829	2,568,019	315,025	3,783	9,733,369
Va., W. Va., Ala.	449,523	1,423,011	280,629	80,228	2,781	2,236,172
Ky. and Miss.	.....	98,378	.....	.....	.....	98,378
Tennessee	.....	208,122	.....	8,616	.....	216,738
Ohio	2,807,761	655,795	1,606,869	207,905	5,096	5,283,426
Ind., Ill., Mich., Col.	2,365,749	249,427	1,036,773	.....	1,079	3,653,028
Wis., Minn., Mo., Cal.	.....	280,240	68,830	.....	11	349,081
Total	11,911,247	4,814,959	5,854,661	738,018	13,359	23,332,244
1913	16,446,722	6,689,680	6,522,075	1,000,172	15,422	30,966,301
1912	16,466,722	6,309,495	6,214,121	726,017	10,582	29,726,937

The number of blast furnaces in the United States at the close of each year since 1909, is given in the following table:

BLAST FURNACES IN UNITED STATES

Fuel Used—Blast Furnaces.	1909.	1910.	1911.	1912.	1913.	1914.
Bituminous coal and coke....	372	382	385	395	394	389
Anthracite, and anth. and coke	48	42	35	26	23	20
Charcoal.....	49	50	45	45	45	42
Total.....	469	474	465	466	462	451

Of the 451 blast furnaces in the United States at the close of 1914, 167 were in blast and 287 were idle. On July 31, 208 were operating and 243 were idle. Thus 44 furnaces shut down during the last half of the year. Detailed figures are given below.

Fuel used—active and idle furnaces.	1913.						1914.					
	First half.			Second half.			First half.			Second half.		
	Active.	Idle.	Total.	Active.	Idle.	Total.	Active.	Idle.	Total.	Active.	Idle.	Total.
Bituminous, chiefly coke.	308	86	394	297	97	394	189	200	389	144	245	389
Anthracite and coke.....	13	8	21	7	14	21	} 5	15	20	3	17	20
Anthracite alone.....	1	3	4	2	0	2						
Charcoal.....	26	19	45	24	21	45	14	28	42	17	25	42
Total.....	348	116	464	330	132	462	208	243	451	164	287	451

In 1914 only three new blast furnaces were projected—two at Cleveland and one at Steelton, Pa. Work on the latter and one of the former was in progress at the close of the year. The capacity of the three will be about 500,000 tons a year. A new stack of the Bethlehem Steel Co., was blown in during the year, with an annual capacity of 150,000 tons. Another stack of the same company was rebuilt, but business conditions were such that it was not lighted. Two furnaces of the Minnesota Steel Co., at Duluth, are still under construction, with a rated capacity of 280,000 tons a year.[1]

STEEL

Steel production of the United States for a number of years past is given in the following table:

[1] *Iron Age*, Jan. 7, 1915.

STEEL PRODUCTION FOR 13 YEARS
(In tons of 2240 lb.)

	Acid.								Basic.		Total.
	Converter.		Open-hearth.		Crucible, etc.		Total.		Open-hearth.		
	Tons.	P.c.	Tons.	P.c.	Tons.	P.c.	Tons.	P.c.	Tons.	P.c.	Tons.
1902	9,138,363	61.2	1,191,196	8.0	121,158	0.7	10,450,717	69.9	4,496,533	30.1	14,947,250
1903	8,592,829	59.1	1,094,998	7.5	112,238	0.8	9,800,065	67.4	4,734,913	32.6	14,534,978
1904	7,859,140	56.7	801,799	5.8	92,581	0.7	8,753,520	63.2	5,106,367	36.8	13,859,887
1905	10,941,375	54.6	1,155,648	5.8	111,196	0.6	12,208,219	61.0	7,815,728	39.0	20,023,947
1906	12,275,830	52.5	1,321,653	5.6	141,893	0.6	13,739,376	58.7	9,658,760	41.3	23,398,136
1907	11,667,549	49.9	1,269,773	5.5	145,309	0.6	13,082,631	56.0	10,279,315	44.0	23,361,946
1908	6,116,755	43.7	696,304	4.9	69,763	0.5	6,882,822	49.4	7,140,425	50.9	14,023,247
1909	9,330,783	39.0	1,076,464	4.5	130,302	0.5	10,537,549	44.0	13,417,472	56.0	23,955,021
1910	9,412,772	36.1	1,212,180	4.6	177,638	0.7	10,802,590	41.4	15,292,329	58.6	26,094,919
1911	7,947,854	33.6	912,718	3.8	129,602	0.4	8,990,174	37.8	14,685,932	62.2	23,676,106
1912	10,327,901	33.4	1,139,221	3.6	142,679	0.4	11,609,801	37.2	19,641,502	62.8	31,251,303
1913	9,545,706	30.5	1,255,305	4.0	155,237	0.5	10,956,248	35.0	20,344,626	65.0	31,300,874
1914	6,220,846	26.5	903,555	3.8	117,500	0.5	7,241,901	30.8	16,271,129	69.2	23,513,030

Shrinkage in the total was from 31,300,874 tons in 1913, to 23,513,030 tons in 1914, a difference of 7,787,844 tons, or 24.8 per cent. Basic open-hearth tonnage for the past year was 16,271,129 tons, 4,073,434 tons, or 20.0 per cent. less than in 1913. Of the 1914 total production, 69.2 per cent. was basic open-hearth material. Bessemer steel output in 1914 was 6,220,846 tons, or 26.5 per cent. of the total. The drop in tonnage was 3,324,860, compared with 1913; a decrease of 34.8 per cent. Of the other grades of steel 903,555 tons, or 3.8 per cent. of the total, was acid open-hearth steel, and 89,869 tons, or 0.4 per cent., was of crucible manufacture.[1]

In the United States at the close of 1914 there were 41 electric furnaces installed for the manufacture of iron and steel, of the following types: Heroult 18, Girod 6, Induction 6, others 11. On July 1, 1913, the total was 19.[2] Electric furnaces produced 24,009 tons of steel in 1914, compared with 30,180 tons in 1913.

In this country 17 new open-hearth furnaces were completed in 1914, with an annual capacity of 1,215,000 tons of steel. Of these, 10 furnaces with a rated yearly output of 795,000 tons, were constructed by independent companies, and 7 with a capacity of 420,000 tons by the Steel Corporation. At the close of the year independent companies had under construction 32 open-hearth furnaces of an aggregate capacity of 1,250,000 tons a year, and the United States Steel Corporation was building 10 furnaces of 500,000 tons rated annual output. Open-hearth furnaces were completed or building during 1914 of capacity sufficient to add nearly 3,000,000 tons of steel to the annual production of the United States.[3]

[1] *Bull. 4, Am. Iron. & Steel Inst.*, 1915.
[2] *Iron Age*, Jan. 7, 1915.
[3] *Iron Age*, Jan. 7, 1915.

Ingot and casting distribution in 1914 was as follows:

	Bessemer.	Open-hearth.	Crucible and Other.	Total.
Ingots	6,154,964	16 570,367	94,453	22,819,784
Castings	65,822	604,317	23,047	693,246
Total	6,220,846	17,174,684	117,490	23,513,030

The production of alloy treated steel in 1914 was 646,953 tons, consisting of 577,107 tons of ingots and 69,846 tons of castings, against 714,357 tons in 1913, consisting of 625,430 tons of ingots and 88,927 tons of castings.

Production in 1914 of leading articles was as follows:

	Iron.	Steel.	Total.
Rails	.....	1,945,095	1,945,095
Plates and sheets	56,590	4,662,656	4,719,246
Nail and spike plates	4,725	38,848	38,573
Wire rods	731	2,430,983	2,431,714
Structural shapes	1,981	2,029,143	2,031,124
Merchant bars	563,171	1,960,460	2,523 631
Reinforced concrete bars	.....	288,471	288,471
Skelp, flue and pipe iron	264,340	1,718,091	1,982,431
Long angle splice and tie plate bars, etc	50,295	372,757	423,052
Hoops	.....	211,028	211,028
Bands and cotton ties	180	345,739	345,919
Rolled sheet piling	.....	35,314	35,314
Railroad ties	.....	33,249	33,249
All other finished rolled product	223,802	714,116	937,918
Forging blooms, billets, etc	500	331,024	331,524
Exports of blooms, billets, sheet bars, etc	1,461	90,446	91,907
	1,167,776	17,202,420	18,370,196

The following table gives leading details of output annually of iron and steel forms, from 1910 to 1914 inclusive.

	1910.	1911.	1912.	1913.	1914.
Rails	3,636,031	2,822,790	3,327,915	3,502,780	1,945,095
Plates and sheets	4,955,484	4,488,049	5,875,080	5,751,037	4,719,246
Wire rods	2,241,830	2,450,453	2,653,553	2,464,807	2,431,817
Structural shapes	2,266,890	1,912,367	2,846,487	3,004,972	2,031,124
Nail plate	45,294	48,522	45,331	37,503	38,573
Bars, skelp, and all other forms	8,475,750	7,316,990	9,908,475	10,030,144	7,204,444
	21,621,279	19,039,171	24,656,841	24,791,243	18,370,196

Rails.—The total production of steel rails in the United States in 1914 was 1,945,095 gross tons, against 3,502,780 tons in 1913; a falling off of 44 per cent. The 1914 output is the smallest since 1908. Below is given the record of rail production for the period 1904 to 1914, according to process of manufacture.[1]

[1] *Iron Age*, Apr. 1, 1915; *Bull.* 2, *Am. Iron & Steel Inst.*, 1915.

PRODUCTION OF ALL KINDS OF RAILS.

Years, Rails.	Open-hearth Steel.	Bessemer Steel.	Rerolled Steel.*	Electric Steel.	Iron.	Total.
1905	183,264	3,192,347	.....	.....	318	3,375,929
1906	186,413	3,791,459	.....	.....	15	3,977,887
1907	252,704	3,380,025	.....	.....	925	3,633,654
1908	571,791	1,349,153	.....	.....	71	1,921,015
1909	1,256,674	1,767,171	.....	†	.....	3,023,845
1910	1,751,359	1,884,442	.....	†	230	3,636,031
1911	1,676,923	1,053,420	91,751	462	234	2,822,790
1912	2,105,144	1,099,926	119,390	3,455	.....	3,327,915
1913	2,527,710	817,591	155,043	2,436	.....	3,502,780
1914	1,525,851	323,897	95,169	178	....	1,945,095

* Rerolled from old steel rails and renewed rails which the manufacturers could not classify as Bessemer or open-hearth. Included with Bessemer and open-hearth steel rails to 1910. † Small tonnages rolled in 1909 and 1910 but not included with Bessemer and open-hearth rails for these years.

Of the total 1914 production, 592,532 tons was rolled in Pennsylvania.

During the year 24 rail mills were active, of which 10 were rerolling mills. Fourteen plants produced open-hearth rails; nine, Bessemer rails; and one (Illinois), electric steel rails.

Open-hearth rails continue to supplant Bessemer, the former making up 78.45 per cent. of the total last year, against 72.16 per cent. in 1913. The following table shows the falling off in tonnage, according to steel processes:

PRODUCTION OF RAILS, SHOWING DECREASE BY PROCESSES, 1913–1914

Kinds.	1914.	Per cent.	1913.	Per cent.	Decrease.	Per cent.
Open-hearth	1,525,851	78.45	2,527,710	72.16	1,001,859	39.64
Bessemer	323,897	16.65	817,591	23.34	493,694	60.38
All other	95,347	4.90	157,479	4.50	62,132	39.45
Total	1,945,095	100.00	3,502,780	100.00	1,557,685	44.47

Included in the above are 136,889 tons of girder and high T-rails in 1914, against 195,659 tons in 1913; and of the above, 121,941 tons represented rerolled rails in 1914, compared with 198,836 tons in 1913.

Production according to weight of section is given below for the period 1904 to 1914:

WEIGHT OF ALL KINDS OF RAILS FROM 1904 TO 1914

Years—Gross Tons.	Under 45 Lb. per Yard.	45 Lb. and Less than 85.	85 Lb. and Over per Yard.	Total Gross Tons.
1905	228,252	1,601,624	1,546,053	3,375,929
1906	284,612	1,749,650	1,943,625	3,977,887
1907	295,838	1,569,985	1,767,831	3,633,654
1908	183,869	687,632	1,049,514	1,921,015
1909	255,726	1,024,856	1,743,263	3,023,845
1910	260,709	1,275,339	2,099,983	3,636,031
1911	218,758	1,067,696	1,536,336	2,822,790
1912	248,672	1,118,592	1,960,651	3,327,915
1913	*270,405	†967,313	2,265,062	3,502,780
1914	*238,423	†309,865	1,396,807	1,945,095

* Include rails under 50 lb. † Include 50 lb. and less than 85 lb.

Included in the totals of rail production are alloy-treated rails, which are shown separately by processes for the years 1909 to 1914. The decline in the use of titanium is noteworthy, as well as its close relation to the ascendency of open-hearth, and the decline of Bessemer tonnage.

	Total Production, Gross Tons.	Production by Alloys		Production by Processes	
		Titanium.	Other Alloys.	Open-hearth and Electric.	Bessemer.
1909	49,395	35,945	13,450	13,696	35,699
1910	257,324	256,759	565	27,389	229,935
1911	153,989	152,990	999	38,539	115,450
1912	149,267	141,773	7,494	40,393	108,874
1913	59,519	47,655	11,864	33,567	25,952
1914	27,937	23,321	4,616	27,447	490

PRODUCTION OF THE U. S. STEEL CORPORATION
Including Tennessee C., I., & Ry. Company

	1909.	1910.	1911.	1912.	1913.	1914.
Iron Ore Mined—	Tons.	Tons.	Tons.	Tons.	Tons.	Tons.
From Marquette Range	899,002	830,094	560,685	551,575	583,266	496,896
From Menominee Range	1,359,415	1,386,465	1,105,044	995,401	980,346	874,909
From Gogebic Range	1,312,701	1,801,480	1,264,734	1,497,950	1,871,700	1,469,601
From Vermilion Range	1,066,474	1,338,110	1,182,075	1,301,663	1,301,163	1,112,854
From Mesabi Range	16,968,592	17,910,366	14,581,530	20,001,953	21,634,206	10,894,463
In Southern Region	1,824,863	1,981,301	1,239,563	2,079,907	2,367,770	2,186,258
Total	23,431,047	25,247,816	19,933,631	26,428,449	28,738,451	17,034,981
Coke Manufactured	13,590,112	13,649,578	12,120,212	16,719,387	16,663,480	11,163,914
Coal Mined, not used in making coke	3,089,021	4,850,111	5,290,671	5,905,153	6,705,381	5,271,911
Limestone Quarried	4,715,708	5,005,087	4,835,703	6,124,541	6,338,509	4,676,479
Blast Furnace Products—						
Pig iron	11,436,570	11,645,510	10,593,726	13,990,329	13,879,706	9,909,062
Spiegel	80,942	102,260	66,435	53,829	65,236	25,397
Ferromanganese and Silicon	100,838	83,628	84,736	142,006	135,788	117,998
Total	11,618,350	11,831,398	10,744,897	14,186,164	14,080,730	10,052,457
Steel Ingot Production—						
Bessemer ingots	5,846,300	5,796,223	5,055,696	6,643,147	6,131,809	4,151,510
Open-hearth ingots	7,508,889	8,383,146	7,697,674	10,258,076	10,524,552	7,674,966
Total	13,355,189	14,179,369	12,753,370	16,901,223	16,656,361	11,826,476
Rolled and Other Finished Products for Sale—						
Steel rails	1,719,486	2,118,473	1,568,028	1,857,407	1,927,745	979,907
Blooms, Billets, Slabs, Tinplate Bars	675,614	682,364	874,474	1,103,752	1,108,147	921,826
Plates	729,790	929,020	630,512	1,076,308	.....	689,241
Heavy Structural Shapes	658,516	656,797	547,186	898,537	998,624	613,739
Merchant Steel, Skelp, Hoops, Bands	1,290,970	1,527,506	1,221,606	1,910,512	2,024,192	1,423,740
Tubing and Pipe	1,013,071	868,550	863,670	1,111,138	1,186,740	818,435
Rods	139,149	133,722	118,302	196,720	174,478	164,153
Wire and Products of Wire	1,607,689	1,490,318	1,613,754	1,629,717	1,432,182	1,380,376
Sheets—Black, Galvanized and Tinplate	1,024,985	1,082,787	1,079,046	1,508,607	1,280,537	1,075,419
Finished Structural Work	530,766	589,228	518,399	599,301	652,363	521,225
Angle and Splice Bars and Joints	190,226	235,998	160,855	192,488	256,676	129,849
Spikes, Bolts, Nuts and Rivets	72,076	71,326	60,386	83,426	86,465	62,133
Axles	68,366	101,066	52,046	142,367	159,075	64,662
Sundry Iron and Steel Products	138,956	246,840	167,984	196,339	245,439	117,159
Total	9,851,660	10,733,995	9,476,248	12,506,619	11,532,663	9,014,512
Spelter	27,853	26,777	28,333	31,318	30,424	28,031
Copperas (Sulphates of Iron)	33,582	33,684	28,381	35,215	33,829	30,212
Universal Portland Cement (Bbl.)	5,786,000	7,001,500	7,737,500	10,114,500	11,197,000	9,116,000

Steel Shapes.—Domestic production of structural shapes was 2,031,124 gross tons in 1914, compared with 3,004,972 tons in 1913,

a decrease of 973,848 tons, or 32.4 per cent. Heavy shapes made up 1,787,281 tons of the total for the year, and light shapes 243,843 tons. During the year structural shapes were rolled in 41 works in 10 states. Pennsylvania made 73.5 per cent. of the total production in 1914.[1]

Wire rods totaling 2,431,714 tons were produced in 1914 by 37 works operating in 12 states. This was a decrease of 33,093 tons from the 1913 figure. Pennsylvania rolled 45 per cent. of the total.

U. S. Steel Corporation.—The year 1914 was the poorest in the financial history of the United States Steel Corporation, and there was a deficit for the year of $16,971,984 after making all deductions. The volume of business for the year was $558,414,933, compared with $796,894,299 in 1913. The industrial operations of the corporation for the past six years are given above

United States imports and exports of iron and steel are tabulated below. Exports decreased from 2,541,485 tons in 1913, to 1,424,244 tons in 1914, a decrease of 1,117,241 tons, or 43.9 per cent. Imports fell off from 302,707 tons in 1913 to 275,290 in 1914, a decrease of 27,417 tons, or 9.0 per cent.

UNITED STATES EXPORTS OF DOMESTIC IRON AND STEEL
(In tons of 2240 lb.)

	1907.	1908.	1909.	1910.	1911.	1912.	1913.	1914.
Pig iron	73,844	46,696	61,999	127,385	120,799	272,676	277,648	114,423
Billets, blooms, etc.	79,991	112,177	104,862	58,230	234,267	294,818	91,847	50,496
Bars	98,654	46,103	87,960	125,606	141,033	230,139	228,331	128,228
Rails	338,906	196,510	299,540	353,180	420,874	446,473	460,553	174,680
Sheets and plates	122,696	104,993	180,048	274,516	372,373	546,968	463,414	280,090
Structural steel	138,442	116,878	90,830	146,721	223,493	288,164	403,264	182,395
Wire	161,228	136,167	149,341	171,928	229,316	244,711	190,282	180,839
Wire-rods	10,653	7,412	20,142	22,869	22,641	65,470	61,636	61,853
Nails and spikes	56,826	38,906	48,055	61,201	77,833	92,497	62,726	49,622
Pipe and fittings	176,832	114,371	162,140	155,728	197,597	249,856	301,784	199,618

UNITED STATES IMPORTS OF IRON AND STEEL
(In tons of 2240 lb.)

	1906.	1907.	1908.	1909.	1910.	1911.	1913.	1912.	1914.
Pig iron	379,828	489,440	92,202	174,988	237,233	148,459	129,325	165,450	138,903
Billets, blooms, etc.	21,337	19,334	12,112	19,913	46,578	29,205	18,702	26,675	49,188
Scrap iron and steel	19,091	27,687	5,090	63,504	72,764	17,272	23,612	44,154	34,849
Bars	35,793	39,746	19,672	19,206	43,692	26,729	26,112	28,243	16,414
Rails	4,943	3,752	1,719	1,513	.....	.....	3,780	10,408	22,571
Wire-rods	17,999	17,076	11,208	10,544	20,374	15,483	15,070	16,097	6,984
Tinplate	56,983	57,773	58,320	62,593	66,640	14,099	2,052	20,680	15,411

The world's production of iron and steel, so far as data are available for the different countries, is noted in the following tables:

[1] *Bull. 3, Am. Iron & St. Inst.*, 1915.

PIG-IRON PRODUCTION OF THE WORLD

(In metric tons)

Year.	Austria-Hungary.	Belgium.	Canada.	France.	Germany.	Italy.	Russia.
1905.....	1,372,300	1,310,290	475,491	3,077,000	10,987,623	31,300	2,125,000
1906.....	1,403,500	1,431,160	550,618	3,319,032	12,478,067	30,450	2,350,000
1907.....	1,405,000	1,427,940	590,444	3,588,949	13,045,760	32,000	2,768,220
1908.....	1,650,000	1,206,440	572,123	3,391,150	11,813,511	112,924	2,748,000
1909.....	1,958,786	1,632,350	687,923	3,632,105	12,917,653	207,800	2,871,332
1910.....	2,010,000	1,852,090	752,090	4,032,459	14,793,325	215,000	3,042,046
1911.....	2,095,000	2,046,280	917,535	4,426,469	15,280,527	302,931	3,521,000
1912.....	2,312,689	2,301,290	1,014,587	4,871,992	17,852,571	379,987	4,197,638
1913.....	(a)1,757,864	2,484,690	1,128,967	5,311,316	19,291,920	426,775	4,547,000
1914.....	.....	.....	783,164	.....	14,389,547	385,114	4,270,000

(a) Austria alone.

Year.	Spain.	Sweden.	United Kingdom.	United States.	All Other Countries.	Total.
1905.....	383,100	531,200	9,746,221	23,340,258	655,000	54,034,783
1906.....	387,500	552,250	10,311,778	25,706,882	650,000	59,171,237
1907.....	385,000	603,100	10,082,638	26,193,863	556,900	60,679,814
1908.....	403,500	563,300	9,438,477	16,190,994	550,000	48,640,419
1909.....	389,000	443,000	9,818,916	26,108,199	550,000	61,217,064
1910.....	367,000	604,300	10,380,723	27,636,687	525,000	66,210,720
1911.....	408,667	633,800	9,718,638	24,027,940	535,000	63,210,694
1912.....	403,243	701,900	8,751,464	30,202,568	.....	.....
1913.....	424,774	735,000	10,481,917	30,966,301	.....	.....
1914.....	.....	635,100	9,005,898	23,332,224	.....	.....

STEEL PRODUCTION OF THE WORLD

(In metric tons)

Year.	Austria-Hungary.	Belgium.	Canada.	France.	Germany.	Italy.	Russia.
1904.....	1,195,000	1,069,880	151,165	2,080,554	8,930,291	113,800	2,700,000
1905.....	1,188,000	1,023,500	403,449	2,210,284	10,066,553	117,300	2,208,000
1906.....	1,195,000	1,185,660	515,200	2,371,377	11,135,085	109,000	2,431,000
1907.....	1,195,500	1,183,500	516,300	2,677,805	12,063,632	115,000	2,600,000
1908.....	2,025,182	1,065,500	598,183	2,727,717	10,480,349	537,000	2,628,000
1909.....	1,969,538	1,370,000	766,795	3,034,571	12,049,834	661,600	3,071,000
1910.....	2,188,371	1,449,500	835,478	3,506,497	13,698,638	635,000	3,479,000
1911.....	2,363,008	2,192,630	880,278	3,680,613	15,019,333	736,000	3,870,000
1912.....	2,785,105	2,515,040	853,031	4,078,352	17,301,998	801,907	4,498,193
1913.....	2,682,619	.....	1,168,993	4,419,241	18,958,819	846,085	4,827,240
1914.....	2,785,105	.....	.....	.....	14,973,106	.....	.....

Year.	Spain.	Sweden.	United Kingdom.	United States.	All Other Countries.	Total.
1904.....	193,759	333,522	5,026,879	13,746,051	415,000	36,148,079
1905.....	264,970	340,000	5,812,282	20,354,291	426,000	43,900,648
1906.....	289,732	351,900	6,462,274	23,772,506	420,000	49,635,998
1907.....	297,684	443,000	6,522,748	23,733,391	405,000	51,273,340
1908.....	301,360	427,100	5,295,642	14,247,619	300,000	44,359,522
1909.....	309,479	310,600	5,881,628	24,338,302	325,000	53,499,974
1910.....	316,301	468,600	6,374,481	26,512,437	315,000	58,656,312
1911.....	322,981	456,500	6,461,612	24,054,918	325,000	58,275,701
1912.....	317,880	508,300	6,796,144	31,751,324	.....	.....
1913.....	365,118	590,887	7,663,876	31,822,555	.....	.....
1914.....	.....	500,600	7,835,113	23,513,030	.....	.....

FOREIGN COUNTRIES

Africa.—Ores from this continent have come to our attention because of shipments of considerable tonnage to the United States in 1914, and the probability of greater importation by eastern furnaces upon revival of the iron industry. Yet the need for these ores in English, Belgian and German furnaces exceeds our own, and in consequence it would appear that the greater profit in their exploitation will come from the European trade, rather than that of this country.

The El Capitan ore is in the Province of Tunis, North Africa. That delivered to this country last year was a soft hematite of Bessemer grade, averaging about 60 per cent. of iron content. A typical analysis is: moisture 2.87, Fe 60.68, S 0.093, Al_2O_3 0.825, SiO_2 4.58, P 0.037 per cent. The mines are about 20 miles back from the port of Bizerta on the Mediterranean, and are in French territory. They have been developed and brought to shipping state in recent years by French capital. The ore-body is very large and so accessible that surface mining is employed. Modern plants for mining, transportation, and storage have been installed, capable of handling about 400,000 tons annually.[1]

Exports of iron ores from Algeria in 1913 were 1,363,000 tons, somewhat more than for the year previous. Of this total, 790,641 tons went to Great Britain, 84,631 to Germany, and 66,281 to Austria.

Austria-Hungary.—As a result of the war, the iron industry of Austria is said to be in a bad state, labor shortage being coupled with financial difficulties. The iron-ore production in 1913 was 3,039,324 tons in Austria alone, as compared with 2,926,686 tons in 1912; the pig-iron production was 1,757,864 tons and 1,759,851 tons.

The total decrease in 1914, as compared with 1913, was 491,860 tons, or 18.3 per cent. Open-hearth steel in 1914 was 89 per cent. of the total, basic converter being 7.3 per cent. The proportional decrease was greatest in converter steel. The loss in production was mainly due to the war conditions in the latter part of the year.

STEEL PRODUCTION OF AUSTRIA-HUNGARY
(Metric tons)

Steel.	1913.			1914.			
	Austria.	Hungary.	Bosnia.	Austria.	Hungary.	Bosnia.	Total.
Acid converter	843	41,738	.....	604	4,009	.....	4,613
Basic converter	232,900	.....	.....	159,500	.....	.....	159,500
Open-hearth	1,500,452	749,711	33,656	1,322,656	607,549	28,520	1,958,725
Crucible	36,653	3,089	.....	16,424	1,133	.....	17,557
Electric	24,902	1,935	.....	18,655	1,189	.....	19,844
Total steel	1,795,750	796,473	33,656	1,517,839	613,880	28,520	2,160,230
Puddled (wrought) iron	44,675	12,065	.....	20,932	9,588	.....	30,520
Total	1,840,425	808,538	33,656	1,538,771	623,468	28,520	2,190,750

[1] *Iron Tr. Rev.*, Jan. 14, 1915.

The Styrian Erzberg still remains the important domestic source of iron ore. The reserves of this mountain of carbonate ore are estimated at 206,000,000 tons of high grade, and 157,000,000 tons of ore of 25 per cent. iron. The present average iron content of 38 per cent. is increased to 45 per cent. by calcination. Sulphur and phosphorus are low. The ore is mined by a series of open platforms or terraces, with hand labor on the upper workings, and steam shovels at the base; the latter take out one-third of the tonnage. The ore is used mainly at the works of Donawitz and Eisenerz. Production in 1913 was 1,950,000 tons.

At the close of 1914 there were 18 electric furnaces in operation in Austria, compared with 10 in the middle of 1913. Ten of these were of the Heroult type, and three were induction furnaces.

Belgium.—The iron industry of Belgium, centered in the district which from the very beginning of the war bore the brunt of the German attack, naturally was entirely demoralized. And with the complete invasion of Belgium, this condition has remained throughout the last half of the year. It is reported that most of the works are intact, and that in many cases—the Cockerill Works at Seraing in particular—operations are being conducted by German military authorities, presumably on repair and construction work for the army.

Production in recent years is given below; the production for the first six months of 1914 was 1,233,410 tons.

PIG-IRON PRODUCTION IN BELGIUM
(In metric tons)

	1907.	1908.	1909.	1910.	1911.	1912.	1913.
Foundry iron....	100,020	76,190	89,960	(a) 83,710	(a) 60,630	(a) 96,620	27,665
Forge iron.....	226,430	127,630	156,590	115,760	102,690	66,940	92,825
Steel pig.....	1,101,490	1,002,620	1,386,800	1,652,620	1,882,960	2,137,730	2,356,040
Total.....	1,427,940	1,206,440	1,632,350	1,852,090	2,046,280	2,301,290	2,476,530

(a) Includes special cast irons.

STEEL PRODUCTION IN BELGIUM

	Bessemer.	Open Hearth.	Castings.	Total.
1905.....	1,095,880	104,550	26,680	1,227,110
1906.....	1,277,010	118,130	45,720	1,440,860
1907.....	1,289,750	176,960	54,900	1,521,610
1908.....	1,070,840	127,160	51,620	1,250,620
1909.....	1,470,400	109,950	52,040	1,632,390
1910.....	1,755,500	136,660	52,660	1,944,820
1911.....	1,971,760	156,410	64,460	2,192,630
1912.....	2,252,380	190,040	72,620	2,515,040

Brazil.—The iron ores of this country still remain only a potential factor in the world's reserves, although estimates place the field as the largest known ore territory in the world, with reserves of upward of 7

billion tons. Transportation difficulties are the principal deterrent to active development. The most important deposits are at Minas Geraes, from 300 to 400 miles back from the coast. For the present, shipment must be made over a railroad with heavy grades and curves to Rio de Janeiro; but a road is now under construction from Minas Geraes to Victoria on the coast, 375 miles long with down grade all the way.[1]

The important deposits at Minas Geraes are hard hematites, of average analysis Fe 69.65, P 0.0125, SiO_2 0.24. The deposits are of sedimentary formation. Itabirite, a granular mixture of iron oxide and quartz sand, forms 95 per cent. of the formation. This is rarely less than 30 per cent. iron content, and grades up into ore. There are several hundred million tons in sight, practically on the surface. There is also an almost incredible amount of lower-grade ore of 60 per cent. iron content and over. These deposits could furnish ores of Bessemer grade with average iron content of 68 per cent. for many years. There has been no exportation up to the present, and it will probably be several years before there is much export, although plans have been made to ship some ore in 1915. French, English, and German interests are getting control of the iron deposits, and are actively engaged in exploration and development.

There has been but little domestic demand, since conditions are not ripe for smelting in Brazil, because of unfit coals and unsatisfactory labor conditions, and a restricted market for iron products.

Magnetites are found in the states of Minas Geraes, Sao Paulo, Santa Catharina, and Parana.

Canada.—Iron-ore shipments from mines in Canada during 1914 are reported as 244,854 short tons. These shipments included 199,292 tons of hematite and roasted siderite, and 45,562 tons of magnetite and concentrates. Compared with the above, 1913 figures were: 307,634 tons total, 92,386 hematite and siderite, 209,886 magnetite and concentrates, and 5362 tons of titaniferous ore.[2]

Exports of iron ore from Canada during 1914 were 135,451 tons, according to Customs Department reports; mine operators' reports, however, show 184,444 tons shipped to Canadian furnaces, and 60,410 tons exported to the United States. United States trade statistics show imports from Canada of 58,816 tons.

Imports of iron ore in 1914 were, according to Customs records, 1,147,108 tons. This includes receipts from Newfoundland of 422,920 short tons.

Canadian blast furnaces in 1914 produced 705,972 gross tons of pig iron, compared with 1,015,118 in 1913. Coke iron represented 690,880 tons of the 1914 total, and charcoal iron, 15,092 tons. At the end of the year there were 6 of the 22 furnaces in blast.

[1] E. C. Harder, *Bull. Amer. Inst. Min. Eng.*, Oct., 1914.
[2] Canada Dept. of Mines, Advance Reports, 1914.

Pig iron production was as follows, according to grades:

	1914.	1913.
Basic	331,456	558,524
Bessemer	184,053	227,662
Foundry	174,346	225,231
All other	16,117	3,701
	705 972	1,015,118

The total production of steel ingots and castings in 1914 was 694,447 tons, 675,691 tons of the former and 18,756 tons of the latter. Open-hearth furnaces produced 549,716 tons, and Bessemer converters 144,447 tons.

The output of finished rolled products was as follows:

	1914.	1913.
Rails	382,334	506,709
Structural shapes and wire rods	59,050	68,048
Plates, sheets, merchant bars	218,125	392,340
	659,519	967,097

Exports of pig iron and ferrosilicon during 1914 were 19,063 tons. Imports for the year were: pig iron 78,680 tons; ferromanganese and ferrosilicon 22,147 tons.

There was agitation in British Columbia for a commission to investigate the iron ore resources of Vancouver Island, and the establishment of an iron and steel industry. The ore is of superior quality, but has been proven only on Texada Island, where estimates of reserves are 20 to 60 million tons. One deterrent to development is the fear of oriental competition.

An increase of import duties was announced on April 6, with three general classes: preferential, to Great Britain and most of the colonies; intermediate, to treaty countries, as France, Belgium, and Austria; general, in which class are the United States and Germany. The following are some typical changes of interest to the iron and steel industry; other increases of corresponding nature were made. Wire rods, formerly free, now $2.25 per ton preferential, $3.50 intermediate and general. Structural steel: preferential from $2.00, formerly, to $4.00, present; intermediate from $2.75 to $6.00; general from $3.00 to $7.00, if such steel can be made in Canada.

Consternation and indignation resulted in the United States on the announcement at the close of the year that the Algoma Steel Co. had entered the market as a seller of rails in that country, and had contracted with certain of the railroads for approximately 50,000 tons. It is understood that the Algoma company has an excess capacity of 100,000 tons to dispose of in the United States, and has made a price sufficiently lower than quotations of domestic mills to move a large proportion of the surplus. The rails will be delivered by the Algoma company in its own vessels to lake ports in the United States. Manu-

facturers in the States have little chance of retaliation, in view of the heavy duty on shipments to Canada, and the additional help derived by the Canadian mills from the bounty.

Chile.—Operations at the Tofo mines of the Bethlehem Steel Co. proceeded steadily in 1914. There was an abundance of labor, due to the closing of the nitrate operations. The ore reserves were materially increased by exploration. No increase of sulphur with increasing depth of ore-body was indicated. A sample from the lowest depth analyzed Fe 67.47, Mn 0.12, P 0.008, S trace, SiO_2 2.00 per cent.

Shipments in 1914 were as existing conditions permitted. The ore was sent by aerial tramway to Cruz Grande and loaded into vessels by a cantilever bridge, now fitted with a conveyor belt. Total shipments in 1914 were 63,000 tons, of which 42,000 tons went to the United States. It is hoped to ship 200,000 tons to Philadelphia in 1915, and gradually increase until the permanent installation is complete, after which annual shipments of 1,500,000 to 2,000,000 tons will be made. Contracts have been made with Swedish shipping interests for five vessels of 17,000 tons capacity each, to be built especially for the Chilean ore trade. The charters are to cover a period of 10 to 20 years at a reported freight of $2.80 per gross ton from Coquimbo to Philadelphia or New York via Panama Canal.

During 1914 a water supply was developed, and a contract let for a concrete dock basin and steel loading dock of 30,000 tons capacity, similar to those on the great lakes. Contracts were also let for an electric railway of standard gauge and 15 miles long, to haul ore from the mines to the sea. Because of the down grade from the mines to the dock, the electric locomotives are equipped for regeneration of power when descending the grade with loaded trains; this will be returned to the lines to assist in hauling empty cars up the grade. The power plant will be erected at Cruz Grande Bay. Oil-fired boilers, steam turbines of 7000 kw. capacity, and alternating-current electric generators will comprise the station equipment.

China (By T. T. Read).—The production of the Hanyang Iron and Steel Works in 1914 was 135,000 tons of pig iron and 98,536 tons of steel. One new blast furnace (the fourth) was completed in the year, and one steel furnace (the seventh). The plate mill and rail mill are being extended and it is planned to construct a new blast furnace. In 1914, 480,000 tons of ore was mined, and new deposits were purchased. An output of 700,000 tons of ore is expected in the coming year. Coke production reached 165,000 tons.[1]

Erection of two additional blast furnaces on the Yangstze River is

[1] *Daily Cons. and Tr. Rept.*, Apr. 19, 1915.

contemplated by the company. This will obviate much present handling difficulty. During the year the company passed to Japanese financial and managerial control. It has been proposed to make the Hanyang works a government enterprise.

A 150-ton blast furnace was blown in in Manchuria by a joint Japanese-Chinese company, and three more are to be erected. The iron deposits are abundant and of high grade, and coking coal and limestone are plentiful and near at hand. Blast furnace plants were also contemplated by English and German interests, but the European war necessitated temporary abandonment of the plans.

Hereafter iron mines in China will be developed by the government, but concessions already granted will not be disturbed.

Japanese investigations of iron ores in Shuntung have disclosed 30,000,000 tons of ore of 65 per cent. iron content. Development work will be undertaken at once, to furnish a supply to Japanese furnaces at present drawing upon Tayeh ores and some from Korea.

Cuba.—Cuban ore shipments to the United States in 1914 were 815,017 tons, the smallest since 1908. In 1913 shipments were 1,582,431 tons, almost double the amount for the past year. Of the 1914 shipments, about 560,000 tons was from the Daiquiri or south coast district, and 250,000 tons from the Mayari or north coast region. Corresponding figures for 1913 were 1,080,728 and 491,713 tons respectively.[1]

The Spanish-American Iron Co. mined and shipped in 1914 about 290,000 tons from its south coast properties, and 250,000 tons from the north coast. During the year this company's properties were operated at about 50 per cent. of capacity, because of reduced blast-furnace activities of the Pennsylvania and Maryland Steel Companies.

The Juragua Iron Co., a subsidiary of the Bethlehem Steel Co., shipped about 220,000 tons, compared with 369,213 in 1913. Mining operations were suspended in September for the rest of the year.

The Punopo Manganese Co. furnished about 60,000 tons of iron ore from its south coast properties to merchant furnaces in the United States during 1914. The mines were closed until the latter part of the year, when operations were resumed because of receipt of considerable business.

Mining operations in Cuba are at present entirely confined to coastal deposits, and to surface workings, and are mainly at the eastern end of the island. It is not improbable that there is much ore in the interior, since exploration work has hardly begun, and has been largely confined to the coast region. The Mayari and Moa-Taco deposits on the north coast are fine, soft limonites, and need nodulizing to better adapt them for the blast furnace and to rid them of excessive moisture. Mining of

[1] C. J. Stark, *Iron Tr. Rev.*, Jan. 14, 1915.

the Mayari deposits is by vertical slicing with drag-line excavators. These reserves, the property of the Spanish-American Iron Co., are estimated at 600 million tons. The ore-bodies are 15 miles from the coast, and the haulage is by cableways. The above company's holdings in the Moa deposits are given as 800 million tons. They are all within 4 miles of the sea.[1]

The Mayari ores caused considerable difficulty in the blast furnace in the beginning, because of low silica, high alumina, and low iron as mined. Nodulizing and drying have given better results, and there is successful operation with some natural ore mixed with the sinter. Typical analysis of dried ore is: Fe 55.57 per cent., SiO_2 4.41, Al_2O_3 14.21, Cr 2.13, Ni 1.04, P 0.022 per cent. The presence of nickel and chromium, the former especially, confers added value to the ore and pig iron.

The south coast deposits near Santiago are magnetites and hard hematites, with some manganese and manganiferous ores. These deposits, while of importance, do not rank with the soft ores in extent. The Bethlehem Juragua reserves are estimated at 500,000,000 tons; the deposit is 17 miles from Santiago. The Spanish-American Daiquiri property is 5 miles from the south coast. Mining is on benches by steam shovel.

Most of the companies are for holding and exploration purposes, and a great deal of the ore properties, particularly in the Camaguay and Pinar districts and in the interior, are held by native, church, and republic interests.

France.—The war zone in France covers the most prominent iron producing sections, as well as the fuel and ore-supply districts. While many of the works fell into the hands of the German invaders, a number of important ones are in territory still held by the French, and these remain active. The full extent of the damage to the industry will not be known until the war is over.

The Lorraine field is the largest iron-ore producing territory in the world outside of the Lake Superior district. In 1914 the output was 14,021,279 metric tons, or 33.7 per cent. less than the output of 1913, aggregating 21,135,554 tons.[2] The field is divided into three sections; Belgian, French, and Luxemburg. The French field has been growing into greatest importance, with the development of the Briey deposit at Longwy, in the Nancy district. The ore is a hydrated hematite, with iron content of 30 to 40 per cent., and phosphorus of basic Bessemer grade. Workings are underground and much water has been encountered. The total reserve of the Lorraine field is estimated at 5 billion tons, of which 60 per cent. is in France. There has been some exportation of

[1] *Min. Eng. World*, Feb. 7, Mar. 14, 1914.
[2] *Jour. Iron & Steel Inst.*, II, (1914).

ore to England, but extensive shipments seem unlikely, because of expense of the 250 miles of rail haul to Dunkirk. Belgium is practically dependent upon Lorraine, and this field is an important source of German supplies of iron ore. Destination of tonnage in the last 2 years was as follows:

	1913.	1914.
Alsace-Lorraine	11,708,964	7,385,682
Saar	2,812,418	1,864,654
Lower Rheinland-Westphalia	2,906,606	2,201,462
Luxemburg	2,896,226	2,102,895
France	517,079	287,662
Belgium	237,035	96,149
South Germany	.....	90
	21,153,382	13,938,594

The mines of Normandy, Brittany and Anjou in the west of France are near the sea, and are possible sources of export to England. German interests acquired concessions in Normandy, to supply Westphalian furnaces. The Normandy ores are hematites of 52 to 55 per cent. iron, and 0.6 to 0.7 phosphorus. There are also carbonates of lower iron content. Anjon and Brittany ores are hematites and magnetites of the same iron and phosphorus contents noted above. The deposits of the triple field are favorably situated for sea transportation. Production is over 1,000,000 tons annually, and two-thirds is exported.

At the close of the year, there were 16 electric furnaces for iron and steel operating in France. This is the same number as in the middle of 1913. The larger number were of the Heroult and Girod types.

Statistics of production of iron and steel in France, so far as available, are given below:

PIG-IRON PRODUCTION IN FRANCE
(In metric tons)

	1906.	1907.	1908.	1909.	1910.	1911. (a)	1912. (a)	1913.
Foundry	591,275	651,700	695,527	749,247	760,622	836,454	825,682	957,145
Forge	741,571	673,885	543,067	538,053	556,767	586,496	568,164	565,133
Bessemer	149,971	122,046	118,121	118,002	104,966	104,265	117,221	161,464
Basic	1,784,726	1,988,343	1,949,107	2,172,718	2,549,908	2,777,261	3,304,518	3,546,057
Special irons	51,489	152,975	85,328	54,085	60,196	122,113	56,407	81,517
Total	3,319,032	3,588,949	3,391,150	3,632,105	4,032,459	4,426,469	4,871,992	5,311,316

(a) As reported by the Comité des Forges.

IRON AND STEEL PRODUCTION IN FRANCE
(In metric tons)

	1906.	1907.	1908.	1909.	1910.	1911.	1912.	1913.
Wrought iron	747,900	687,249	563,745	519,200	501,100	462,681	(e)450,000	.....
Steel ingots	2,436,322	2,766,773	2,727,617	3,034,571	3,506,497	3,680,613	4,078,352	4,419,241
Finished steel	1,454,456	2,261,217	1,894,022	2,043,022	2,684,000	2,638,484	3,028,799	2,993,050

(e) Estimated.

Germany.—Production of iron and steel in Germany, which for the first 7 months of 1914 was at the rate maintained in the year previous, received a severe setback at the outbreak of the war. Mobilization of the army withdrew large numbers of men from mining and works operations, and movement of troops interfered with transportation of material needed in the industries. After the mobilization there was an industrial revival in certain districts, and the authorities, after urgent representation by the works, set aside some rolling stock for the conveyance of raw materials and manufactured goods. Gradual resumption of operations was undertaken as far as labor conditions permitted. There was a material advance in price in all classes of iron products, from the low notch figures of the second quarter of 1914, to those at the close of the year.

Exports were entirely cut off, but domestic demand was great, especially in war supplies. Some difficulty was encountered in securing iron-ore supplies, since importation was limited to such cargoes as were received from Sweden.

Germany has obtained almost complete possession of the Lorraine ore field, the most important in Europe, but production of any magnitude, especially in the French and Belgian sections, is hardly possible so long as this section remains in the active war zone. It is reported that there is some activity in the mines, chiefly to prevent flooding.

German importations of iron ore for the first half of 1914 are reported as 6,748,052 metric tons, compared with 6,843,645 tons in the same period of 1913.

Pig-iron output for 1914 was 14,389,547 metric tons, against 19,309,172 in 1913, a decrease of 25.49 per cent. For the first months of the war, production declined to about one-third of the previous rate, but at the close of the year recovered to the extent that operations were about 50 per cent. of normal. Monthly figures are as follows:

	Metric Tons.	
	1913.	1914.
January	1,611,345	1,566,505
February	1,493,877	1,445,511
March	1,629,463	1,602,896
April	1,588,701	1,534,429
May	1,643,069	1,607,193
June	1,609,748	1,531,313
July	1,648,818	1,564,345
August	1,640,016	586,661
September	1,599,849	580,087
October	1,653,051	729,822
November	1,588,985	788,956
December	1,611,250	853,881
Total	19,309,172	14,389,547

Production of pig iron by kinds for several years past is noted below:

PRODUCTION OF PIG IRON IN GERMANY
(In metric tons)

	1907.	1908.	1909.	1910.	1911.	1912.	1913.	1914.
Foundry iron.	2,259,416	2,254,644	2,491,919	2,968,810	2,881,059	3,355,177	3,640,074	2,494,527
Forge iron...	786,113	635,228	652,306	644,992	689,881	525,423	489,783	370,257
Steel pig.....	1,034,650	934,940	1,099,779	1,327,196	1,547,480	2,201,489	2,599,887	1,996,786
Bessemer pig.	471,355	361,472	412,118	471,366	377,051	388,855	368,840	237,988
Thomas pig..	8,494,226	7,627,227	8,261,538	9,338,961	9,785,056	11,397,965	12,193,336	9,289,989
Total.....	13,045,760	11,813,511	12,917,653	14,793,325	15,280,527	17,868,909	19,291,920	14,389,547

The following table gives the production according to districts.

PRODUCTION ACCORDING TO DISTRICTS

	Tons, 1913.	Tons, 1914.
Rhenish-Westphalia	8,209,157	6,610,119
Siegerland and Hessen-Nassau	994,927	702,436
Silesia	994,604	853,957
North and Central Germany	1,001,321	734,659
South Germany and Thuringia	320,456	266,065
Saar District	1,370,980	954,738
Lorraine and Luxemburg	6,417,727	4,267,573
Total	19,309,172	14,389,547

The German Iron & Steel Works Union reports a steel production for the year of 14,973,106 metric tons, as against 18,958,819 tons in 1913, a decrease of 21 per cent. From an average of 1,570,000 tons per month up to the war period, output fell to 566,822 tons in August, but gradually increased to 941,399 tons in December. At the close of 1914 there were 245 steel-making plants in operation. Itemized figures of steel production are as follows:

PRODUCTION OF STEEL IN GERMANY
(In metric tons)

	1911.		1912(a).		1913.		1914.	
	Acid.	Basic.	Acid.	Basic.	Acid.	Basic.	Acid.	Basic.
Converter ingots...	187,359	8,640,164	187,179	9,794,300	155,138	10,629,697	100,617	8,269,600
Open-hearth ingots	383,895	5,668,501	295,256	6,871,896	380,155	7,592,901	361,564	6,518,874
Special steels.....	139,414	.....	153,367	.....	200,928	.....	184,432	184,432
Total (b).....	710,668	14,308,665	635,802	16,666,196	736,221	18,222,598	646,613	14,973,106

(a) As reported by the German Iron & Steel Union. (b) Includes direct castings.

Germany produced 89,336 tons of electric steel in 1914 in 46 furnaces installed by the close of the year. This compares with the 34 furnaces of this kind in use in June, 1913. Of the forty-six, 19 are Heroult, 6 Girod, and 18 of the induction type.

Great Britain.—As a result of the war, the trend of events in the British iron and steel industry suffered a complete reversal of form during 1914.[1] At the beginning of the year the condition of the trade was far from satisfactory, and gloomy prophecies found justification in the subsequent 6 months. In the early summer prices were at a point where business was practically unremunerative to makers, and there appeared every prospect of indefinite continuance of dismal conditions. With the commencement of the war, however, the iron and steel trade took on a new lease of life, and for the balance of the year continued to flourish in a manner hardly to be contemplated at the beginning of the year. The changed circumstances were due almost entirely to government demand for war material. The elimination of England's two most active competitors, Belgium and Germany, from the foreign export field, had some bearing upon the situation; not so much in enabling Britain to absorb the business in foreign fields, as in cutting out the severe competition in the home markets.

Labor troubles and shortage, shipping dangers and high freight charges, and financial stress, have at intervals caused embarrassment to the industry.

At the beginning of the year 1914, Cleveland pig iron was quoted at $12.15, and this figure prevailed for the early months. There was an advance to $12.40 during April, which lasted until July. Considerable disturbance was caused by the outbreak of the war, resulting in a price advance to $12.85 in August. This was followed shortly by a reversion to $12.40, and a steady decline for the rest of the year. November quotations were $11.90. In the other pig-iron making centers there were fluctuations of a more violent character, with marked advances at the outbreak of the war, followed by a reaction to figures as low or lower than those prevailing in the earlier months of the year.[2]

In steel and finished products there has been no adherence to a definite trend; specialized demand and cutting off of foreign competition in certain lines, have caused greater fluctuations in some products than in others. Heavy steel shapes advanced from $32.15 in the middle of July to $34.60 a month later. The latter figure was maintained throughout the rest of the year. Ship plates advanced from $29.10 to $35.20. On heavy products in general the advance was not excessive, impending competition from America being responsible to a large degree.

The British tinplate industry had a bad year, a large part of the mills being inactive, and production was very much below capacity. The war, cutting off the best foreign markets of the trade, restricted operations

[1] *Min. World*, Jan. 16, 1915.
[2] J. Horton, *Iron Tr. Rev.*, Jan. 7, 1915.

enormously, and at the end of the year output was about 50 per cent. of capacity, and prices were at a low figure.

The British Iron Trade Association reports the production of pig iron in Great Britain in 1914 at 9,005,898 tons, which was 1,476,019 long tons, or 14.1 per cent. less than in 1913. Output was divided almost equally between the first and second half year. Production began to fall off early in 1914 on account of industrial depression, and was not seriously affected by the outbreak of the war. Production statistics are given in the following table, divided according to classes of pig iron:

	1912. Tons.	1913. Tons.	1914. Tons.
Forge and foundry	3,431,727	3,943,139	3,430,448
Bessemer and hematite	3,408,386	4,057,700	3,235,403
Basic	1,771,771	2,125,689	2,003,693
Spiegel, ferro, etc	277,240	355,389	336,354
Total	8,889,124	10,481,917	9,005,898

By districts, Scotland, the Northeast Coast, Cumberland and South Wales made all the low-phosphorus iron—bessemer and hematite. The Northeast Coast (Middlesboro) and Lancashire were the larger makers of basic pig. Middlesboro, Cumberland and North Wales made the ferro-manganese and spiegeleisen.

The production of pig iron for 10 years past has been as follows (in long tons):

1905	9,592,737	1910	10,217,022
1906	10,149,388	1911	9,718,638
1907	9,923,856	1912	8,889,124
1908	9,289,840	1913	10,481,917
1909	9,664,287	1914	9,005,898

The make of pig iron in 1914 was the smallest of any year in the 10 except 1912. It follows the year of largest production. At the close of 1914, 294 furnaces were in blast, or six more than on September 31.

The output of steel in Great Britain in 1914 was the largest for the past 10 years or more, and was 171,237 tons, or 2.2 per cent., over the production of 1913. Statistical data are as follows:

ACID AND BASIC STEEL IN THE UNITED KINGDOM
(In tons of 2240 lb.)

	1912.			1913.			1914.		
	Acid.	Basic.	Total.	Acid.	Basic.	Total.	Acid.	Basic.	Total.
Open-hearth	3,365,570	1,908,087	5,273,657	3,811,382	2,251,793	1,600,701	3,680,848	2,874,749	6,555,597
Converter	980,662	541,825	1,522,487	1,048,772	551,929	6,063,175	797,072	482,444	1,279,516
Total	4,346,232	2,449,912	6,796,144	4,860,154	2,803,722	7,663,876	4,477,920	3,357,193	7,835,113

PRODUCTION OF STEEL IN THE UNITED KINGDOM
(In tons of 2240 lb.)

	1904.	1905.	1906.	1907.	1908.	1909.	1910.	1911.
Open-hearth..	3,245,346	3,879,748	4,554,936	4,663,489	3,817,103	4,148,408	4,595,366	5,000,472
Bessemer....	1,781,533	2,009,712	1,907,338	1,859,259	1,478,539	1,733,220	1,779,115	1,461,140
Total.....	5,026,879	5,889,460	6,462,274	6,522,748	5,295,642	5,881,628	6,374,481	6,461,612

During 1914 Great Britain exported 3,977,468 gross tons of iron and steel; of this total 1,157,715 tons war shipped out in the 5 months of the was period. In 1913, 5,928,441 tons was exported; the decrease in 1914 was 1,950,973 tons, or 32.9 per cent. Complete data are given below:

IRON AND STEEL EXPORTS, UNITED KINGDOM
(In tons of 2240 lb.)

	1908.	1909.	1910.	1911.	1912(a).	1913(a).	1914.
Pig iron.....	1,295,767	1,136,369	1,205,863	1,204,319	1,124,815	1,097,009	780,691
Wrought iron.....	172,072	170,189	141,747	138,089	142,461	137,335	90,405
Sheets.....	390,281	494,826	597,117	617,557	762,244	762,744	566,601
Plates.....	207,278	167,797	250,867	267,691	282,898	273,051	199,878
Rails.....	435,739	571,524	485,693	370,543	412,127	509,105	443,636
Steel shapes, etc. ..	275,022	305,530	369,020	347,828	361,992	368,498	300,653
Tin plates.....	403,007	439,804	483,020	484,355	480,910	495,246	435,497
All other kinds.....	921,810	932,024	1,208,578	1,088,727	1,211,102	1,295,453	1,071,546

(a) From official Trade and Navigation Accounts.

India.—During the year some lots of pig iron have been sold and delivered on the Pacific coast, and there was a selling campaign on the Atlantic seaboad. It is claimed that pig iron can be made at $6 per ton, and steel ingots at $15, with possibility of lower costs with increased operating efficiency. Freight to the Pacific Coast is $5 to $6.[1]

The Tata Iron and Steel Co. has works in Bengal, 155 miles west of Calcutta. Operations began in December, 1911, with native capital and labor, and foreign management, and the plant is an assured success. There are coke ovens, two 250-ton blast furnaces, four 40-ton open-hearth furnaces, and rolling mills for rails and shapes. Annual output is 150,000 tons of pig iron, 110,000 tons of ingots, and 75,000 tons of finished steel.[2]

Italy.—Pig-iron production and imports were as follows; practically all was for maker's own consumption in steel manufacture.

	1912.	1913.	1914.
Coke.....	370,132	420,283	378,243
Charcoal.....	3,021	4,711	2,371
Electric furnace.....	2,500	160	4,500
	375,653	425,154	385,114
Imports.....	267,355	221,688	219,995
	643,008	646,842	605,109

[1] *Iron Tr. Rev.*, July 23, 1914.
[2] *Min. Prese*, Jan. 16, 1915.

Korea.—(By T. T. Read).—The Mitsui Mining Co., of Japan, is exploring the iron deposits which it has acquired in the Chusinmen district, its concession covering 8000 acres. The deposit appears to be of large extent, and averages over 55 per cent. iron, with some ore as high as 70 per cent. in iron.

Newfoundland.—Total shipments from the Wabana mines in 1914 were 639,430 net tons; 422,920 tons went to Sydney, Cape Breton, and 216,510 tons to the United States and Europe. In 1913, total shipments of 1,605,920 tons were recorded, 1,048,432 tons going to Canada, and 557,448 tons to the United States and Europe. Curtailment of shipments to the United States and Canada, together with cancellation of German contracts because of the war, necessitated a closing down of the Wabana mines for several months, after large stocks had been accumulated. Some surplus tonnage on German contracts was diverted to England.

The total reserve of the Wabana deposit is estimated at 1 to 2 billion tons of recoverable ore of good quality. Only a small portion is on land; here mining is carried on by stripping and quarrying. The greater proportion of the ore is obtained by underground working of the submarine deposits. The ore is a dense red hematite with 51–55 per cent. iron, 10–11 silica, 0.085 phosphorus, and practically no sulphur. The Nova Scotia Steel & Coal Co. holds 45 sq. mi. of the basin, and the Dominion Iron & Steel Co., 10 sq. mi.[1]

New South Wales.—The first shipments of iron ore have been made from Hummocky Hill for treatment at the Newcastle Smelting works. Development of the industry is expected. The ore runs 68 per cent. in iron, and a large supply is in sight, estimated at 21,000,000 tons, and capable of opencut mining. There is a haul of 33 miles to seaboard. The first blast furnace at Newcastle will turn out 10,000 tons of pig iron per month. Orders have been booked for 2500 tons of rails for the New South Wales government, and 2000 tons for the South Australian government, at preferential prices, higher than outside quotations.[2]

New Zealand.—Enormous deposits of iron sands are found in the various coastal regions. They are mainly magnetic oxide, some of it auriferous. Terms for the right to work some of the deposits have been asked of the government by a Glasgow firm. The company would construct a large plant at once, and would require an ample supply close to shipping for a considerable period of years.[3]

Russia.—As a result of the war there was an entire suspension of operations in the coal- and iron-producing centers of Poland, but activities continued in the Urals and South Russian fields. Production was

[1] *Iron Tr. Rev.*, June 18, 1914.
[2] *Min. Jour.*, Apr. 10, 1915.
[3] *Austral. Min. Stand.*, Apr. 16, 1914.

lower than normal because of a scarcity of labor, and difficult transportation. No coke could be received from Germany.

Production statistics are as follows:

PRODUCTION OF IRON AND STEEL IN RUSSIA
(In metric tons)

	1906.	1907.	1908.	1909.	1910.	1911.	1912.	1913.
Iron ore	4,580,000	4,400,000	4,450,000	4,750,000	4,595,000	6,881,000	8,077,000	.....
Pig iron	2,350,000	2,768,220	2,748,000	2,871,332	2,740,000	3,593,164	4,197,638	4,547,000
Steel ingots	1,763,000	2,076,000	2,341,000	2,477,000	2,350,000	3,945,597	4,498,193	4,837,240

Pig-iron production for 1914 is estimated at 4,270,000 metric compared with 4,547,000 tons in 1913. The falling off was entir the last half year. Of the above tonnages, 3,008,000 was from S Russia in 1914, and 3,005,000 in 1913. On January 1, 1914, this di had 50 furnaces operating, and on January 1, 1915, 43 out of 60 1914 South Russia produced 2,314,000 tons of finished iron and against 2,275,000 tons in 1913.

Foundry pig iron was quoted at the works at $21.42 in Jan 1914, and $22.39 in December. Steel ingots were $32.36 throughou year, and rails $34.06.

Russian imports of iron and steel products in 1914 were 2 tons of merchant shapes, 4,700 tons of tinplate, sheets, etc., and tons of wire and wire manufactures.

A history of the development of the South Russian iron and deposits is given by J. W. Revillon.[1] Large deposits of excellent her are found at Krivoy-Rog, ironstone in the Coal Measures, lower- oolitic ore at Kertch, and manganese ore at Nicopol; while the deposits in the Donetz basin are among the most important in the Progressive development of the iron industry began in 1869, wit entrance of English capital and direction, and the aid of goverr contracts and subsidies, and later by protective duties and imp shipping facilities. Ore deposits have been opened and developed there has been an influx of foreign and domestic capital. At the pr time, 18 plants are in operation with an aggregate output of 3,000,000 tons of pig iron per year, equal to 70 per cent. of the production of the Russian Empire. The works are in the main sit between the coal and iron deposits.

Spain.—Exports in 1914 were 6,083,193 metric tons of iror compared with 8,097,309 tons in 1913. Total iron ore output in was 9,861,663 tons.

Sweden.—According to the report of the Swedish Ironmasters'

[1] *Iron & Coal Tr. Rev.*, Feb. 19, 1915.

ır 1914, the war resulted in a decrease in the export trade and consequently a considerable decrease in production. The abnormally dry weather and the lack of water for the works were contributory causes. The on and steel works during the latter part of 1914 maintained production at about the level to which it was reduced by the outbreak of the ar. During the period August–December there were from 63 to 66 last furnaces in operation out of a total number of 124, and 110 to 134 ancashire hearths out of 260. At the end of the year only 45 out of he existing 75 open-hearth steel furnaces were operating, while of 24 essemer converters only 6 were working.

The production figures for 3 years past were as follows, in metric ons:

	1912.	1913.	1914.
ig iron	699,800	730,300	635,100
uddled (wrought) iron	148,800	158,500	113,300
onverter steel	107,300	115,800	93,000
pen-hearth steel	404,100	469,400	407,600

During the winter months of 1914 an abundant supply of charcoal was available, though the imports of coal were obstructed and prices were 50 per cent. higher on account of freight rates. The rise in coal prices was particularly felt, since the lack of water involved iron-works in a greater use of coal.

The exports showed a heavy decrease, most of which was due to the war. The foreign trade was as follows for 2 years past, in metric tons:

	1913.	1914.
Pig and scrap	194,100	167,400
Ferro and spiegel	21,400	12,200
Ingots, blooms, etc	59,700	34,800
Wire rods	38,900	27,500
Iron bars	154,800	103,000
Other iron and steel	33,700	38,100
Totals	502,600	383,000

Of the total decrease, 84,000 tons was in the 5 months August–December.[1]

Exports of ore fell off in the latter part of the year to 50,000 tons monthly, compared with a normal amount of 200,000 tons. Total shipments for 1914 were 5,000,950 tons, or 1,459,000 tons less than in 1913. Swedish imports of pig iron were 103,200 tons in 1914, compared with 94,600 tons in the year previous.

At the end of the year there were 18 electric furnaces installed for the production of iron and steel, an increase of 12 over the number in

[1] *Eng. Min. Jour.*, Mar. 20, 1915.

June, 1913. The greater proportion were small furnaces for the manufacture of steel castings and the higher or special grades of steel.

Venezuela.—Venezuelan ore, which promised to be a big factor in supplies for furnaces in the eastern part of the United States, ceased to be of any importance during 1914. Shipments to this country from that source were only 2400 tons, compared with 59,000 tons in 1913. The dropping out of this ore was due to deterioration in quality of the Imataca ore and the abandonment of development of these deposits along the Orinoco River by the Canadian-Venezuelan Ore Co. As a result of the decline in iron content, a contract made in 1913 for 500,000 tons of ore to be delivered in 100,000-ton annual installments was canceled by the Alan Wood Iron & Steel Co. The present outlook for the Imataca properties is very uncertain.[1]

Technology

In conformity with the state of depression in the iron and steel industry, economy has been the keynote in technical development, with interest centering upon increased efficiency of operation, recovery of by-products, or improvement in quality of product.

Fuels.—By-product coking has developed in the direction of increased size of ovens, with greater conservation of heat and lowering of coking time, so that the modern oven will coke as high as 20 tons per day, compared with the 4 to 5 tons in the earlier days. United States progress in this respect has been in advance of that of Europe. Coking times have been cut to 15 hr. or less, with no deterioration of quality of product for blast-furnace use.

In Europe the more modern ovens are being arranged with double regenerators, to operate at will on coke-oven or blast-furnace gas for heating. If the latter, regeneration of both gas and air is necessary. The change can be made to either gas without loss of time. The surplus coke-oven gas of high calorific power finds outlet for open-hearth and other heating furnaces. Tests of Dr. Biermann[2] have shown reduced coking time by the use of blast-furnace gas, and a more even oven heating because of greater volume of gas. And the flameless combustion avoids stoppage of oven mains by tar, etc., and necessitates less cleaning of burners and flues. The life of the open-hearth, on the other hand, is increased by the substitution of coke-oven gas for all or part of the producer gas.

The vertical type of retort oven is being developed, and one plant is reported in operation. Decreased investment costs are claimed, and if this is true, and is coupled with successful and controllable coking,

[1] *Iron Tr. Rev.*, Jan. 14, 1915.
[2] *Jour. Iron & Steel Inst.*, II (1914).

production of by-product coke should increase rapidly, since the high capital charges of the present styles of ovens are the chief drawback to development.

Considerable attention has been given, especially in the Chicago district, to the control of the physical quality of the coke and its suitability for blast-furnace use.

The recovery of benzol from by-product coke gas has for some time been an integral part of the operation in Germany; the letting of contracts about the middle of the year by the Carnegie Steel Co., at Farrel, Pa., marked the inception of such installations in this country. Activity in this direction is keen, and such plants are being erected or considered by the Lackawana Steel Co., Buffalo; Tennessee Coal, Iron & Railroad Co., Ensley, Ala.; Lehigh Coke Co., South Bethlehem, Pa.; Carnegie Steel Co., Farrell, Pa.; Cambria Steel Co., Johnstown, Pa.; and Republic Iron & Steel Co., Lansingville, Ohio.

With growing scarcity and uncertainty of fuel oil and natural gas supply, there has been increasing interest in producer gas. Studies are in progress of its manufacture from low-grade fuels. Also, in the line of economy of manufacture, and in economy and efficiency of utilization, great interest is being manifested in the thorough cleaning of the gas, and in the possible recovery of by-products, as is practised in coking. O. Wolff[1] notes that if all of the ammonium sulphate were recovered from Westphalian coal, it would have a greater value than the coke. And if the coal were gasified and the by-products obtained, the electric power plus the sulphate would have a value about twice that of the sulphate, gas, coke, tar, and benzol resulting from present practice. The Lunn process, similar in principle to the Mond, but with a less costly plant, is described.

Larger producers, to replace the numerous smaller units now standard, seem desirable. Producers with zonal movement, or other mechanical stirring to reduce the ratio of carbon dioxide to a minimum, have been adopted to a considerable degree, and slagging types for use with certain coals are being developed.

F. W. Steere[2] describes the experiments on the detarring of gas by electrical means, in a manner somewhat similar to that of Cottrell for the precipitation of smelter dust and fume, but by the use of high-tension alternating current instead of rectified direct current. The success of the experimental plant at the Detroit works of the Semet-Solvay Co. resulted in the installation at the Ford Motor Co. of a commercial plant for cleaning producer gas, which has had several months of successful operation

[1] *Stahl. u. Eisen*, Mar. 19, 1914.
[2] *Am. Gas Inst.*, Oct., 1914.

The Minnesota School of Mines[1] is investigating the possibilities of peat as a metallurgical fuel, both as a source of producer gas and as peat coke. The Minnesota bogs are close to the mines, and the fuel, if economical, would have outlet as a source of electrical energy for sintering, roasting, etc., and to replace charcoal in the manufacture of pig iron.

The use of pulverized coal has made progress, and it is now being extensively used as a fuel for heating furnaces of various types. The application to open-hearth steel furnaces has proven satisfactory and economical.

Refractories.—There has been considerable concern regarding supplies of magnesite, due to the cutting off of the Austrian supply as a result of the war. The lack of magnesite has led one of the important Southern interests to a greater use of dead burned dolomite, for bottoms as well as patching, and it is stated that they will probably never go back to the use of magnesite to the same degree heretofore thought necessary.

Zirconia has been experimented with in Germany, and an open-hearth furnace bottom lined with this material was in good condition after 4 months of continuous service, and apparently good for as much more before renewal. It is very refractory and resistant to metals, but more costly than magnesite.[2]

Iron Ore.—The suitability of iron ores for use in the blast furnace has received much attention. It is now recognized that with increasing fineness of ore, agglomeration becomes more desirable, and results in decreased flue dust, in more effective reduction, and in markedly better economy of fuel through elimination of the solution loss of coke accompanying the use of fine ore. Agglomeration has found favor chiefly in the utilization of flue dust, but the advantages are so apparent that the treatment will no doubt be applied to increasing proportions of the fine ores of the charge. Briquettes are not much favored in this country, although they hold first place in German opinion. Satisfactory test runs were made with 72 per cent. of briquettes in a furnace charge, and there was considerable decrease of blast pressure and coke consumption and increased output and yield, with improved quality of product, due to steady operation.[3]

A Grondal briquetting plant has been in successful operation at a Wisconsin works, and the blast-furnace operation has been benefited by the charge of 60 per cent. briquettes and 40 per cent. lake ore. Strong briquettes are made from the friable local Clinton ore, and scaffolding and flue dust have been greatly reduced. Coke consumption has decreased and the furnace output is greater than with raw ore alone.[4]

[1] *Iron Tr. Rev.*, Aug. 27, 1914.
[2] *Met. Chem. Eng.*, Dec., 1914.
[3] *Iron Age*, Mar. 19, 1914.
[4] *Eng. Min. Jour.*, Nov. 21, 1914.

Experiments of L. Mathesius[1] on the reducibility of briquettes, nodules and sinters of different ores indicated the best results with briquettes. In general, materials agglomerated by heat behaved like the more difficultly reducible magnetites, and there was a tendency to melt and require solid carbon for reduction. Their chief advantage lay in lessened liability to scaffold.

Nodulizing kilns are employed in sintering the Cuban ores, accomplishing the double purpose of eliminating excessive moisture and agglomerating the dusty ore. Powdered coal is used as fuel.

The Dwight-Lloyd down-draft sintering process, originally devised for roasting, has been successfully adapted to iron ores, and several plants are now using this method for the sintering of flue dust, as well as a proportion of the fine-ore charge.

Magnetic concentration of the New York magnetites has become more and more necessary, and the method is described. Such separation results in elimination of much gangue material, as well as the phosphate constituents, and crude ore of 35 per cent. iron and 0.085 phosphorus is enriched to 65 per cent. iron and 0.018 per cent. phosphorus.[2]

With a constantly lowering grade of available ores, preliminary preparation at the mines has attracted attention, both as a means of bettering the burden and because of a profit due to saving in transportation of waste matter. With the lean ores of the South, washing has been the practice for years, with a concentration ratio as high as 6:1. This method is now being practised to raise the grade of Mesabi ores. Also, driers are proving successful in eliminating the excessive moisture and combustible matter from certain Lake Superior ores. In experiments on the paint rocks of the Mesabi, upward of 20 per cent. of useless matter was eliminated by sintering, and a material of better physical character for the furnace was obtained. By this method many ores now in the twilight zone may become available for use.[3]

Blast Furnaces.—Much progress has been made in this field in the past year, both in a better understanding of operation and control and in the adoption of accessories for more economical operation or the more efficient utilization of raw materials or by-products. Physical quality of stock—ore, fuel and flux—and its proper distribution, while recognized for a long time as being most important factors in successful furnace operation, have been put upon a plane of better understanding by interchange of ideas through publication and discussion.

Perhaps the most important paper of the year was that of H. A. Brassert,[4] dealing with the developments in American blast-furnace

[1] *Stahl u. Eisen*, May 21, 1914.
[2] *Iron Tr. Rev.*, Aug. 6, 1914.
[3] *Iron Tr. Rev.*, June 18, 1914.
[4] *Am. Iron & Steel Inst.*, May, 1914.

practice. Records of performance and experiment at one of the largest plants in the country were given, and the evolution and development based upon observation. Quality and physical character of raw materials were discussed, and the importance of these features in both ore and coke, as influencing direct and indirect reduction, were pointed out as factors in operating economy. Air supply, charging, and progress in furnace lines were also treated.

No feature has received more recognition than that of proper cleaning and combustion of blast-furnace gas. In the best practice all gas for stoves and boilers is washed after preliminary cleaning in dust catchers, resulting in a saving of gas and increased efficiency of combustion, and greater effective capacity of stoves and boilers. The virtual elimination of cleaning of stoves and flues has reduced costs of operation, and practically wiped out one of the serious hazards of the blast-furnace employee. Stove checker spaces can be reduced to a size entirely impracticable where dust accumulations would soon choke up the passages.

Wet cleaning of the gas has a disadvantage in the lessened efficiency of combustion due to the moisture content. The Beth-Halberg process of dry cleaning has been developed in Germany. The gas is cooled, then slightly superheated to eliminate wet steam, and finally filtered in a bag chamber. Exceptionally clean, dry gas results at a low cost of operation, but with increased first cost of plant.[1]

A large plant in the Central West has adopted an improved burner of a modified Bunsen type, for stoves and boilers. Better and cleaner combustion and effective regulation of flame are obtained by an arrangement of orifices and annular dampers for gas and air supply.

The Pfoser-Strack-Stumm system for heating blast-furnace stoves has been an important development of the past year in Germany.[2] Usual practice in this country, with four stoves, requires 3 hr. for heating, as against 1 hr. for abstraction of the heat by the blast. Experiments supported the reasoning that the variation in the rate of heat transfer was largely due the lessened velocity of gas travel, as compared with that of the blast. By greater rapidity of heating, due to blowing in compressed air for combustion through a special nozzle, it was possible to get entire uniformity of blast heating by two stoves in series per furnace, one on gas and the other on air for equal times. Some criticism has been raised regarding the practicability of this system under our conditions of operation. It is contended that the stoves of the German furnace were abnormally large, per unit of furnace capacity, compared with those of this country. The so-called forcing, therefore, was not forcing at all, compared with our standards.

[1] *Jour. Iron & Steel Inst.*, I (1914).
[2] *Jour. Iron & Steel Inst.*, II (1914).

In furnace lines the tendency has been toward a larger hearth and lower boshes. The thin lined shell has not been entirely successful, and preference is now for a medium thickness of inwall brickwork, which will withstand service conditions without water cooling.

The importance of proper top filling has been recognized. That this is best accomplished by mechanical distributors is not universally conceded. No new devices have appeared during the year. In Europe, however, there has been installed at a few plants a telpherage charging system, with an automatically controlled block system of handling. Charges are handled from bins to furnace top without manual supervision of individual skips. At one works in Germany the telepherage system is handling the charges for six furnaces with a combined daily output of 1500 tons.[1]

A controversy has been waged at the technical society meetings, between the advocates of gas, reciprocating steam, and steam-turbo blowing engines. The operating economy of the former is an established fact; its chief disadvantage is high plant investment. The turbo blower is comparatively a newcomer into the field, and naturally has received the greatest publicity in reports of plant installations and operations. Claims for better furnace operation and economy are made, based largely upon the greater regularity of blast and uniformity of pressure. Advocates of the reciprocating engine contend that such regularity may be of advantage in converter blowing, but not for the blast furnace. They admit that the turbo may be installed at less cost, but is more wasteful of steam; much more so, in fact, if turbo figures are compared with the newer types of reciprocating engine working with high vacuum and superheat. An expression of opinion by many operating men is that the turbo is satisfctory awhile there is regularity in the furnace conditions, but that it tends to fall down if irregularities cause obstruction of blast, at a time when most needed.

The steam turbine of mixed-flow type has found a place as an auxiliary in plants where the question of investment prevents replacement of an existing non-condensing steam engine plant.

Experiments have been conducted with a view to further utilization of blast-furnace slag.[2] Favorable results are reported where the air-cooled slag has been used as concrete aggregate. The slag makes an aggregate of a light-weight, puzzolanic, alkaline and permanent nature. Sulphur content and weathering, especially in basic slags, are points for careful consideration.

The high heat content of slags has prompted efforts to utilize this in raising steam. At one plant in England the method is to run the slag

[1] *Jour. Iron & Steel Inst.*, II (1914).
[2] *Am. Soc. Test. Mat.*, July, 1914.

into a granulating hopper, from which it is carried out by a double conveyor system with water-sealed trap. The direct steam, because of the sulphur content, is used to evaporate fresh water for use in low-pressure turbines. Experiments indicate a generation of 31 h.p. per ton of slag.[1]

A series of important papers dealing with blast-furnace construction and operation, from the pen of J. E. Johnson, Jr.,[2] has appeared during the year, and forms a noteworthy contribution to the literature of the subject. Subdivisions treated during the year covered the handling of raw materials, the boiler plant, blowing apparatus, stoves, stack construction, and gas cleaning and utilization. Other noteworthy papers are those of Cornell[3] giving results of a carefully worked out analysis of the heat balance data of a large blast-furnace plant; and of F. E. Bachman, describing in detail the experimental work on the blast-furnace reduction of the titaniferous iron ores of New York. The latter receives consideration in the Titanium section of this volume.

Steel Works.—While there has been little actual development in steel-making processes during the year, much good has resulted from several important papers and discussions of various processes and their details of practice and relative merits. Duplexing has received considerable attention, and typical plants and methods of operation are described. Several plants in the United States and Canada are now using the duplex process for all or part time. Usual practice is partial conversion in the acid-lined converter, with finishing and removal of phosphorus in a basic open-hearth furnace.[4]

One of the most important papers of the year was that of Dr. F. Schuster,[5] on a comparison of the Talbot process with other open-hearth processes, made at Witkowitz, Austria. The evolution at these works has been through acid Bessemer, then basic Bessemer, and finally an acid Bessemer-basic open-hearth duplex combination. Too high costs finally led to an extended study, first by inspection trips and then by exhaustive work tests, of the various steel-making methods, with the result that the Talbot process has been adopted as best suited to Witkowitz conditions. Lower costs for fuel and tonnage, higher yield, longer furnace life, simplicity of operation, greater adaptability to varying charges, and an increased value of the slag because of concentration in phosphoric acid were factors in favor of the Talbot process. This conclusion is rather opposite to the tendency in the United States, where the

[1] *Jour. Iron & Steel Inst.*, II (1914).
[2] *Met. Chem. Eng.*, Mar. to Dec., 1914.
[3] *Met. Chem. Eng.*, Dec., 1914.
[4] *Iron Age.*, Jan. 7, 1915; *Bull. Amer. Inst. Min. Eng.*, Oct., 1914.
[5] *Jour. Iron & Steel Inst.*, I (1914)

duplex method is finding greater favor, probably because of greater speed in working, with consequent lower investment charges per ton.

The power question has received much attention, with a decided tendency toward the use of electricity for all requirements in modern rolling mills. This is well illustrated in the equipment of the new plant of the Bethlehem Steel Co., where there is no steam drive or steam auxiliaries. Gas-engine power generation and 3-phase, 6600-volt induction-motor drive is used throughout the plant. Electric motors have now been developed for the heavy service of reversing, blooming and billet mills, thus broadening the field of utility of electric drive.[1] While the steam engine can change its speed more rapidly than the motor, the latter has no tendency to race as the ingot leaves the rolls. In the Ilgner system, on cutting off the power, the motor reverses its function and acts as a generator, braking itself and returning energy to the motor-generator set. The net result is a speed of rolling with a reversing mill at least as fast as with steam-engine drive.

Where existing steam plants cannot be discarded, or where such engines are necessary for heavy mill drives, the low-pressure or the mixed-flow types of steam turbine are finding much favor. A decided saving in fuel is reported, and in certain instances such installations have made it unnecessary to extend boiler plants, or have even made it possible to shut down parts of existing ones. In one mill a 350-h.p. mixed-pressure turbine has been successfully used for driving an 18-in. roughing mill, through a special type of reduction gearing.[2]

An important study of J. Puppe[3] on roll pressures in forming certain standard sections is reported. All of the tests showed that safe stresses in the rolls are always exceeded, and that the pressures are much higher than usually assumed. Surface stresses on roll bearings are noted, also the distribution of power losses.

The Tennessee Coal, Iron & Railroad Co. has under construction at its Ensley, Ala., works a plant for the manufacture of phosphate fertilizer from the slag of the open-hearth furnace. Operating upon the duplex system, there is initial concentration of the phosphorus, due to elimination of the greater part of the silica in the converter slag. By special manipulation of double slags in the tilting open-hearth furnaces, a slag of 20 to 25 per cent. of phosphoric acid is obtained, which makes a good fertilizer after pulverizing.

The electric furnace has made progress in the steel-casting and special steel industries. The low fuel economy of ordinary types of melting furnaces, especially those of small capacity, together with the

[1] *Am. Iron & Steel Elec. Engrs.*, Dec., 1914.
[2] *Iron Tr. Rev.*, Nov. 26, 1914.
[3] *Stahl. u. Eisen*, Jan. 1, 1914.

possibility of a high degree of refining in the electric furnace because of high temperatures and controllable atmosphere and slags, has enabled the electric furnace to hold its own on a strictly competitive unit cost basis; or because of higher quality of product, to compete in those fields where high selling prices put small differences in unit melting costs into the background. For the larger capacity furnaces of the steel works, substitution of the electric furnace is hardly to be expected; the latter has, however, continued to serve as an auxiliary in those plants where it was installed as the finishing unit in the Bessemer-electric duplex combination, chiefly in the production of alloy or special steels.

For the production of pig iron from the ore, the electric furnace has proved rather disappointing during the past year. Development proceeded to the point where, with charcoal available as the reducing agent, and electrical energy at reasonable cost, pig iron could be produced at profit in competition with existing supplies. However, development of any magnitude, or outside of zones with special local conditions, pointed to the necessity of large furnaces, and especially of a type adapted to the use of coke as a reducing agent.

Experiments along the above line at Hardanger, Norway, were unsatisfactory. The high conductivity of coke required lower operating voltages and higher currents, while the higher sulphur necessitated more lime flux, which in turn increased the dead ballast in the furnace. While good pig iron could be produced, and improvement in yield was obtained after trial and betterment of electrical features, the temperature variations in the smelting zone resulted in non-uniformity of product. Power costs were excessively high, compared with other plants using charcoal, and results of 0.57 to 1.16 tons of pig iron per h.p. year, as against 1.74 to 2.45 tons at other plants, are noted.[1]

The California operations have continued, and furnace developments have been made, but coke has proved unsatisfactory. At Notodden, Norway, however, four furnaces are producing 40 tons of pig iron daily with coke as reducing agent, and successful operation is claimed, with power consumption not materially higher than that at other places where charcoal is used.

The Helfenstein furnace, of the open-hearth type and of extremely large size, has been in successful operation at Domnarfvets, Sweden, producing pig iron from ore. Charcoal is used as reducing agent, but it is claimed that coke can be used after proper adjustment of the voltage. An output of 65 tons per 24 hr. has been reached.[2]

Lyon and Keeney review the history and development of electric

[1] *Met. Chem. Eng.*, Feb., Apr., July, 1914.
[2] *Iron Age*, Aug. 27, 1914.

furnaces for the manufacture of iron and steel, and give descriptions and operating details of important plants in this country and abroad.[1]

Quality of Iron and Steel.—Interest has continued in the improvement of the quality of steel, with the chief development one of gradual betterment through coöperation between manufacturer and user. The steel-rail problem has continued to force the issue, and attention has been centered upon the chemical nature of the steel, the improvement of quality by securing better ingots through reduction of piping and segregation, and the securing of the best physical characteristics of any steel through proper working and handling in the rolling mill.

The most radical innovation is that introduced by Mathias at the Lackawanna Steel Co. After partial roughing-down of the bloom, the surfaces for a depth of about ⅛ in. are milled off between two cutters 5 ft. in diameter. In this way the decarbonized surface zone is removed, as well as superficial ingot cracks, which, it is claimed, are the primary cause of seams and flange breakages in the rail.[2]

The concensus of opinion among railroad men is that the roads do not want heavier sections than are now general. In such sections there is insufficient penetration of the work, and a rail of coarser texture results. If heavier rails are necessary, R. W. Hunt contends that means must be devised to ensure more effective work on all sides, perhaps by some form of universal mill.[3]

The Bureau of Standards has done considerable research work on methods for measurement of finishing temperatures in rolling rails. Such temperatures were satisfactorily determined by optical pyrometers, and comparative tests were made on the relation of physical quality, micro-section, and rolling conditions. In the discussion of the paper, the general opinion of rail experts was that the tests so far made are not confirmatory nor consistent in proving or disproving the theory that quality or grain size are a function of the finishing temperature.[4]

The controversy with regard to the cause of internal transverse defects is still waged between two factions divided largely as manufacturer and user; all are agreed, however, that sound metal is absolutely essential to ensure service under modern traffic conditions.

Of the alloy steel rails, those with manganese additions are finding increasing favor for exceptionally severe service. Titanium rails have largely lost out, with the very general substitution of open-hearth for Bessemer steel, while vanadium additions, heretofore too costly, are now being tried out with results which are claimed to be promising as regards wear and freedom from brittleness.

[1] *Bull.* 67, Bureau of Mines.
[2] *Am. Soc. Mech. Eng.*, Dec., 1914.
[3] *Bull. Am. Inst. Min. Eng.*, Feb., 1914.
[4] *Bull. Am. Inst. Min. Eng.*, Oct., 1914.

Some changes have been made in the standard specifications for rails by the leading technical societies. For the present, at least, 0.80 carbon is considered to be the maximum safe limit.

Steady progress may be noted in the field of alloy steels and heat treatment, chiefly in a better understanding of the underlying principles. Case hardening and the annealing of steel and malleable cast iron have been benefited by much needed investigation. The American Society for Testing Materials has adopted standard specifications for the heat treatment of case-hardened steel and for the annealing of steel castings.[1]

Tungsten steel has been adopted for the valves of automobile and other gas engines, and vanadium steel has given increased life when used for dies and heavy shear blades. German tests on the effect of boron additions to steel have shown increased hardness and brittleness in proportion to the amount of boron added, and a lack of malleability even when hot.[2]

There has been little halt in the controversy between the two factions concerned with the metallography of iron and steel—the believers and non-believers in beta iron and its influence on the hardening of steel. The discussion has been of an international character, and has been participated in by eminent authorities. Carefully conducted investigations of the Bureau of Standards on the critical points and electrical resistance leave little room for doubt that there are transition points in pure iron corresponding to those commonly ascribed to the alpha, beta, and gamma changes.[3] Whether such changes are allotropic depends upon our conception of allotropy. Manganese steel has furnished the topic for much discussion, because of its peculiar properties and the intimate relation of their causes and those underlying the hardening of steel.

One of the most interesting contributions of the year was that of McCance[4] to the theory of hardening. It was the result of very carefully conducted and interpreted experiments on the hardness, electrical resistance, density, and magnetic properties of carbon steels, and a close study of the work of others. The net result of the investigation is that iron has but two transformations of importance: alpha, free from carbon in solid solution; and gamma, holding carbon in this manner. If, in the transition from one state to the other, such transition is not completed, non-homogeneity of crystalline orientation is the result, and a hardness similar to that caused by interstrain is the result. Quenching of carbon steel produces this effect, as does the presence of certain foreign elements through their influence on the reaction velocity.

[1] *Amer. Soc. Test. Mat.*, 1914.
[2] *Stahl u. Eisen*, Sept. 24, 1914.
[3] *Bull.* 236, Bureau of Standards.
[4] *Jour. Iron & Steel Inst.*, I (1914).

In many respects the McCance hypothesis is not unlike the old internal tension theory of Metcalf and Langley.

Another contribution on hardening, based upon crystal twinning, was presented at the same meeting as the McCance paper, but did not meet with much approval as an adequate explanation of the causes.[1]

The corrosion of iron and steel is beginning to attract attention worthy of its importance as a metallurgical problem. The relative merits of various grades of product, and particularly pure iron as compared with ordinary open-hearth and copper-bearing steels, is naturally an unsettled question, and still a matter of controversy. Time must elapse, and consistent results after repeated tests under varying conditions are necessary to back up any contention. A most important step in the right direction is the institution by the American Society for Testing Materials of an elaborate series of tests in different parts of the country, and on the various classes of material.

Foundry practice has continued its advances through interchange of ideas and presentation of results of experiment. This policy has done much to lift foundry methods out of the rut of the rule of thumb. Efficient management, labor-saving devices and machinery of higher efficiency, and the improvement of materials and product have been the subjects of fruitful discussion.

The most radical and important development of the year in cast iron is the apparently successful efforts of J. E. Johnson, Jr.,[2] to improve the quality of cast iron or pig iron of ordinary coke grade, and make it the equal of the higher priced charcoal iron. Long study of good and bad irons led to the conclusion that oxygen was the underlying influence. Whatever the form of combination, the fact was that for irons of otherwise identical analysis, those containing oxygen to a considerable extent were stronger and of better chilling quality than irons containing less of this element. The probable effect of the oxygen is in changing the character of crystallization of the iron, and in closing the grain by making balls of the graphite, instead of flakes. The observations are being developed into a commercial method for the improvement of cast iron. An artificial mixture is made of ordinary pig iron with a partially blown Bessemer metal, in which the silicon has been removed to allow oxygenation.[3]

A somewhat similar method has been patented in Germany. White iron is blown in a converter and mixed with ordinary pig iron or cupola metal. The effort in this case is to get a product of less than 3 per cent. total carbon (practically impossible in cupola metal) in a more satisfactory manner than by the addition of steel to pig iron.[4]

[1] *Jour. Iron & Steel Inst.*, I (1914).
[2] *Bull. Amer. Inst. Min. Eng.*, Feb., 1914.
[3] *Am. Found. Assn.*, Sept., 1914.
[4] *Stahl. u. Eisen*, Nov. 27, 1913; *Iron Age*, Feb. 26, 1914.

LEAD

By H. B. Coho

The most interesting features of the lead industry for 1914 is the remarkable fact that the output increased 80,000 tons over 1913, the greatest gain on record, and this in spite of the fact that 1914 must go down in history as a poor business year. Another peculiar feature is the fact that the average price for 1914 was below 4 cts., the lowest average price in 16 years. The year 1914 has absolutely reversed all precedent in the history of the lead business as in the panics of 1893 and 1907 the low prices decreased production. The great production of 1914 further indicates that this country can produce a large quantity of lead cheaply, and that the high protective tariff which remained in force for so many years retarded rather than helped the industry. It also would seem to allay the apprehension heretofore prevalent in regard to a 4-cent lead market. Another interesting feature of 1914 is the resumption of lead exports after a lapse of nearly 40 years, and while some of this must be attributed to the conditions abroad, there is every reason to feel that some of this business will be retained after normal conditions are restored in Europe. The imports of lead in 1914 showed a decline of 50 per cent. largely due to troubles in Mexico.

The year 1914 was marked by an enormous increase in the output of domestic lead in the United States, according to C. E. Siebenthal, of the U. S. Geological Survey—an increase of nearly 80,000 tons over the production of any preceding year. There was also a heavy decrease in the tonnage of lead of foreign origin treated in the United States and for the first time in years a great increase in the quantity of domestic lead exported to European countries. At the same time the average price of lead in the United States was the lowest since 1898.

The estimates have been compiled from reports to the Survey by all lead refineries and soft-lead smelters in operation during the year. The statistics of imports, exports, and lead remaining in warehouses have been taken from the records of the Bureau of Foreign and Domestic Commerce.

Production

The production of refined lead, desilverized and soft, from domestic and foreign ores in 1914 was 542,122 short tons, worth at the average

New York price $42,285,516, compared with 462,460 tons, worth $40,696,480, in 1913, and with 480,894 tons in 1912. The figures for 1914 do not include an output of 16,668 tons of antimonial lead, against 14,667 tons in 1913 and 13,552 tons in 1912. Of the total production, desilverized lead of domestic origin, exclusive of desilverized soft lead, is estimated at 311,069 tons against 250,578 tons in 1913 and 221,480 tons in 1912; and desilverized lead of foreign origin comprised 29,328 tons, compared with 50,582 tons in 1913 and 88,377 tons in 1912. The production of soft lead, mainly from Mississippi Valley ores, is estimated at 201,725 tons, compared with 161,300 tons in 1913 and 191,614 tons in 1911, the largest prior output of soft lead. The total production of lead, desilverized and soft, from domestic ores, was 512,794 tons, 100,916 tons more than in any previous year and 25,000 tons more than the total output of the country from both domestic and foreign sources in any previous year.

METALLURGICAL PRODUCTION OF LEAD IN THE UNITED STATES (a)
(Refinery Statistics. In tons of 2000 lb.)

Year.	Domestic Origin.						Foreign Origin.		Grand Total.
	Desilverized.	Antimonial	S. E. Mo.	S. W.Mo.	Miscel.	Total.	Desilverized.	Antimonial	
1909...	211,499	10,392	126,784	20,489	*Nil.*	369,164	89,681	2,338	461,183
1910...	217,490	9,098	145,387	20,729	*Nil.*	392,704	90,473	4,892	488,069
1911...	211,041	8,916	155,008	25,993	*Nil.*	400,958	89,487	4,929	495,374
1912...	236,207	9,239	145,336	19,224	*Nil.*	410,006	82,715	5,003	497,724
1913...	261,616	16,345	133,203	22,312	*Nil.*	433,476	54,774	2,300	490,550
1914...	318,286	15,642	177,320	22,125	*Nil.*	533,373	24,624	543	558,540

(a) From *Eng. Min. Jour.*

Imports and Exports

The imports of lead are estimated at 11,825 short tons of lead in ore, valued at $750,334; 16,365 tons of lead in base bullion, valued at $1,116,730, and 148 tons of refined lead, valued at $10,082—a total of 28,338 tons valued at $1,877,146, compared with 57,147 tons, valued at $2,965,817, in 1913. Of the 1914 imports 23,134 tons, or over four-fifths, came from Mexico, against 47,840 tons in 1913 and 79,672 tons in 1912, the decrease being due to domestic strife in that country. From Germany came 2,265 tons, from German East Africa 1278 tons, and from Chile 1,205 tons.

The exports of lead of foreign origin smelted or refined in the United States again show a big decrease, being 30,944 tons, against 54,301 tons in 1913 and 76,226 tons in 1912.

For the first time in years there were exports of domestic lead to Europe, the total for the year amounting to 58,722 short tons, valued at $4,501,684.

Lead Available for Consumption

IMPORTS OF LEAD, IN ORE, BASE BULLION, AND REFINED, BY COUNTRIES, 1908–1913, IN POUNDS

Country.	1908.	1909.	1910.	1911.	1912.	1913.	1914.
United Kingdom.	399,569	191,243	1,874,750	401,686	279,546	404,594	245,548
Germany.....	695,151	2,821,967	421,377	56,286	494,237	262,132	4,529,919
Other European countries.	1,699,509	1,385,616	418,669	111,189	55,356	143,293	123,085
British North America .	1,291,044	4,133,755	206,979	270,947	319,497	338,569	384,007
Mexico.....	219,567,193	215,203,714	203,290,307	172,633,479	159,455,664	95,693,439	46,282,207
South America...	469,770	1,942,847	6,598,263	4,778,221	3,207,936	8,766,727	2,417,744
Other countries..	26,418	2,683,950	4,394,421	1,651,544	3,309,365	8,685,612	2,094,293
Total imports.	224,148,654	228,363,092	217,204,766	179,903,352	167,121,601	114,293,966	56,676,803

IMPORTS OF LEAD, BY CLASSES, 1907–1912, IN POUNDS

Year.	Lead in Ore (Lead Content).	Base Bullion.		Pigs, Bars, Sheets, and Old.	Total Lead Content.[1]
		Gross Weight.	Lead Content.[1]		
1907.....	64,815,254	76,259,828	74,594,313	18,554,899	157,964,466
1908.....	64,708,204	153,921,829	150,560,176	5,518,621	220,787,001
1909.....	71,357,868	149,852,559	146,579,779	7,152,665	225,090,312
1910.....	94,751,054	118,061,415	115,483,542	6,970,170	217,204,766
1911.....	35,686,180	141,481,852	138,952,372	5,264,800	179,903,352
1912.....	19,577,499	152,420,624	146,999,168	544,925	167,121,592
1913.....	19,883,313	96,908,170	94,327,654	82,999	114,293,966
1914.....	23,649,637	33,444,503	32,730,320	296,846	56,676,803

[1] Lead content of bullion for 1907–1909 estimated on the basis of average lead content of imports of base bullion in 1910.

PRIMARY REFINED LEAD AVAILABLE FOR CONSUMPTION IN THE UNITED STATES
(Short tons)

	1910.	1911.	1912.	1913.	1914.
Supply:					
Stock in bonded warehouses Jan. 1.....	17,405	35,972	4,481	10,492	5,310
Imports—					
For consumption.....	15,359	13,281	14,146	11,980	7,286
For warehouse.....	93,249	76,671	69,414	45,165	20,952
Production from domestic ores.....	375,402	391,995	392,517	411,878	512,794
Total supply.....	501,415	517,919	480,558	479,515	546,442
Withdrawn:					
Exports of foreign lead—					
From warehouse.....	69,786	101,227	64,906	44,544	21,545
In manufactures, with benefit of drawback.	8,800	12,080	11,320	9,757	9,200
Exports of domestic lead.....	.....	.....	.....	.....	58,722
Decrease by liquidation.....	7,661	14,812	5,692	419	56
Stock in bonded warehouses Dec. 31.....	35,972	4,481	10,492	5,310	7,666
Total withdrawn.....	122,219	132,600	92,410	60,030	97,200
Available for consumption.....	379,196	385,319	388,148	419,485	449,052

[1] U. S. Geol. Surv.

The amount of lead available for consumption during 1914 may be estimated by adding to the stock of foreign lead (domestic stocks are not known) in bonded warehouses at the beginning of the year (5310 short tons), the imports (28,338 tons), and the domestic production (512,-

794 tons), making an apparent supply of 546,442 tons. From this is to be substracted the foreign lead exported from warehouse (21,545 tons), the foreign lead exported in manufactures under drawback (9,399 tons), the exports of domestic lead (58,722 tons), the decrease by liquidation, (56 tons), and the stock in bonded warehouses at the close of the year (7668 tons), leaving as available for consumption 449,052 tons, compared with 419,485 tons in 1913, 388,148 tons in 1912, 385,319 tons in 1911, and 379,196 tons in 1910. Taking into account trade conditions during the year, this seems to be an excessive figure, making it seem very probable that there has been an increase in lead stocks. Of the foreign lead remaining in warehouses at the close of November, 1914, there was at El Paso 2176 short tons and at New York 4846 tons, with small quantities at Chicago and St. Louis.

The Lead Market in 1914

The great point of interest in the lead market for 1914, is that in spite of the 80,000-ton increase in production, no material advance in price could be maintained, indicating that this country's supply of lead is abundant, and that competition is very keen among the producers.

The first quotation on lead in 1914, was 4.15 cts., New York, which price prevailed until Jan. 9, when it was reduced to 4.10; at this price buying was stimulated to such an extent that on Feb. 2 the price advanced to 4.15 cts. The independent producers began at this time to shade prices, and to take business in such quantities that on Feb. 11, the American Smelting and Refining Co. reduced its price to 4 cts. During February the London market, where the absence of the usual Mexican supply was keenly felt, became very strong, and early in March the difference in prices resulted in the sale of some Missouri lead for export. This was the beginning of a very important export business. Owing to poor business in the building trades and chemical industry, the domestic market continued to sag, and some pressure having developed to sell Missouri lead, the American Smelting and Refining Co. on March 25 reduced its price to 3.90 cts. New York, and on March 30 a still further reduction of 3.80 cts., New York was made, at which figure some large tonnages were turned over.

From April 1 to April 27 the lead market was without special features, but about the end of the month consumers apparently made up their minds that lead was low and that threatening conditions in Mexico tended to raise prices, and considerable buying developed, with the result that the American Smelting and Refining Co. on April 27 raised their price to 3.90 cts., New York, at which price lead remained throughout May and

June without any noteworthy change or feature. The export business continued strong during this period.

Although the export business continued, the great production began to be felt early in July, and it was apparent that even with the great subtraction from stocks, the stock of lead in the hands of producers was reaching an unheard of quantity, and there was talk of curtailing production, but apparently those interested were unable to come to an agreement. The A. S. & R. Co. during July maintained the New York price unchanged, but some weakness appeared at St. Louis. When the European war cloud finally burst, there was no material effect on the lead market. A feeling of possible higher prices was indulged in for several weeks, but by September all hope for an advance on account of the war had disappeared. All of the producers had large stocks, and a desire to turn them into money resulted in a selling movement, which broke prices, and on Sept. 24 the A. S. & R. Co. reduced their price to 3.75 cts., New York, practically on a parity with the St. Louis market.

From September 24 to October 5 the independent producers continually cut prices, until the A. S. & R. Co. on October 5 reduced their price to 3.60 cts. and on Oct. 7 to 3.50 cts., temporarily demoralizing the market. A price level had to be found which would move the unsold stock. About the middle of October the producers in Missouri and Idaho curtailed production from 25 to 50 per cent. Impressed by this curtailment consumers bought freely and continued to do so during November. The increased buying justified the advance on Nov. 12 to 3.60 cts. N. Y., and on Nov. 17 to 3.70 cts., but on Nov. 19 the price was raised to 3.90 cts., which caused a cessation of orders, and on Nov. 27 the price was reduced to 3.80, where it remained during December, there being very little feature to the market for the balance of the year.

The prices for lead at New York named by the A. S. & R. Co. were as follows:

	Lb.		Lb.		Lb.
Opened	4.15 cts.	March 30	3.80 cts.	Nov. 12	3.60 cts.
Jan. 9	4.10	April 27	3.90	Nov. 17	3.70
Feb. 2	4.15	Sept. 24	3.75	Nov. 19	3.90
Feb. 11	4.00	Oct. 5	3.60	Nov. 27	3.80
March 25	3.90	Oct. 7	3.50	Dec	3.80

The Price of Lead in London.[1]—During August, September and October, the London Metal Exchange was closed and there was no official price there, except that fixed arbitrarily for August. For September and October no official price was fixed, so far as we can find out. However,

[1] From *Eng. Min. Jour.*, Jan. 16, 1915.

the following prices were quoted by some of the London dealers during that period.

September				September			
8	£19			21	£19	2s.	6d.
9	19			22	19	5	
10	19	7s.	6d.	23	19	5	
11	19	5		24	19	7	6
14	19	5		25	19	7	6
15	19	5		28	19	5	
16	19	5		29	19		
17	19	5		30	18	5	
October				**October**			
1	£18	5s.		16	£17	6s.	9d.
2	18	2	6d.	19	17	8	9
5	18	2	6	20	17	10	
6	18	1	3	21	17	10	
7	17	18	9	22	17	10	
8	17	17	6	23	17	10	
9	17	16	3	26	17	12	6
12	17	12	6	27	17	11	10
13	17	12	6	28	17	12	6
14	17	10		29			
15	17	5					

No quotations are available for the first 7 days of September.

AVERAGE MONTHLY PRICE OF LEAD PER POUND IN NEW YORK

Year.	Jan.	Feb.	Mar.	Apr.	May.	June.	July.	Aug.	Sept.	Oct.	Nov.	Dec.	Year.
	Cts.	*Cts.*	*Cts.*	*Cts.*	*Cts.*	*Cts.*	*Cts.*	*Cts.*	*Cts.*	*Cts.*	*Cts.*	*Cts.*	*Cts.*
1900...	4.68	4.68	4.68	4.68	4.18	3.90	4.03	4.25	4.35	4.35	4.58	4.35	4.37
1901...	4.35	4.35	4.35	4.35	4.35	4.35	4.35	4.35	4.35	4.35	4.35	4.15	4.33
1902...	4.00	4.075	4.075	4.075	4.075	4.075	4.075	4.075	4.075	4.075	4.075	4.075	4.069
1903...	4.075	4.075	4.442	4.567	4.325	4.210	4.075	4.075	4.243	4.375	4.218	4.162	4.237
1904...	4.347	4.375	4.475	4.475	4.423	4.196	4.192	4.111	4.200	4.200	4.200	4.600	4.309
1905...	4.552	4.450	4.470	4.500	4.500	4.500	4.524	4.665	4.850	4.850	5.200	5.422	4.707
1906...	5.600	5.464	5.350	5.404	5.685	5.750	5.750	5.750	5.750	5.750	5.750	5.900	5.657
1907...	6.000	6.000	6.000	6.000	6.000	5.760	5.288	5.250	4.813	4.750	4.376	3.658	5.325
1908...	3.691	3.725	3.838	3.993	4.253	4.466	4.477	4.580	4.515	4.351	4.330	4.213	4.200
1909...	4.175	4.018	3.986	4.168	4.287	4.350	4.321	4.363	4.342	4.341	4.370	4.560	4.273
1910(*a*	4.700	4.613	4.459	4.376	4.315	4.343	4.404	4.400	4.400	4.400	4.442	4.500	4.446
1911(*a*	4.483	4.440	4.394	4.412	4.373	4.435	4.499	4.500	4.485	4.265	4.298	4.450	4.420
1912(*a*	4.435	4.026	4.073	4.200	4.194	4.392	4.720	4.569	5.048	5.071	4.615	4.303	4.471
1913(*a*	4.321	4.325	4.327	4.381	4.342	4.325	4.353	4.624	4.698	4.402	4.293	4.047	4.370
1914(*a*	4.111	4.048	3.970	3.810	3.900	3.900	3.891	3.875	3.828	3.528	3.683	3.800	3.862

(*a*) From *Eng. Min. Jour.*

AVERAGE MONTHLY PRICE OF LEAD PER 2240 LB. AT LONDON (*a*)
(In pounds sterling)

Year.	Jan.	Feb.	Mar.	Apr.	May.	June.	July.	Aug.	Sept.	Oct.	Nov.	Dec.	Year.
1900....	16.296	16.542	16.612	16.733	16.900	17.225	17.533	17.633	17.667	17.596	17.229	16.233	16.987
1901....	15.925	14.667	13.379	12.421	12.275	12.342	12.150	11.692	11.954	11.600	11.267	10.533	12.521
1902....	10.567	11.617	11.508	11.596	11.600	11.271	11.233	11.121	10.892	10.746	10.717	10.754	11.262
1903....	11.304	11.708	13.225	12.404	11.800	11.437	11.383	11.146	11.167	11.108	11.108	11.179	11.579
1904....	11.558	11.592	12.037	12.254	11.754	11.521	11.667	11.737	11.787	12.187	12.892	12.775	11.983
1905....	12.875	12.462	12.296	12.658	12.762	13.000	13.608	13.958	13.950	14.679	15.337	17.050	13.719
1906....	16.850	16.031	15.922	15.959	16.725	16.813	16.525	17.109	18.266	19.350	19.281	19.609	17.370
1907....	19.828	19.531	19.703	19.975	19.688	20.188	20.350	19.063	19.775	18.531	17.281	14.500	19.034
1908....	14.469	14.250	13.975	13.469	12.938	12.600	13.000	13.375	13.125	13.375	13.538	13.156	13.439
1909....	13.113	13.313	13.438	13.297	13.225	13.031	12.563	12.475	12.781	13.175	13.047	13.125	13.042
1910....	13.650	13.328	13.063	12.641	12.550	12.688	12.531	12.513	12.582	13.091	13.217	13.197	12.920
1911....	13.009	13.043	13.122	12.889	12.984	13.260	13.530	14.260	14.744	15.332	15.821	15.648	13.970
1912....	15.597	15.738	15.997	16.331	16.509	17.588	18.544	19.655	22.292	20.630	18.193	18.069	17.929
1913....	17.114	16.550	15.977	17.597	18.923	20.226	20.038	20.406	20.648	20.302	19.934	17.798	18.743
1914....	19.665	19.606	19.651	18.225	18.503	19.411	19.051	(*b*)	(*b*)	(*b*)	18.500	19.097	.....

(*a*) The statistics for 1897–1905 are from the report of the Metallgesellschaft, Frankfurt-am-Main Those for subsequent years are from the *Eng. Min. Jour.* (*b*) London exchange closed.

The Cost of Producing[1]

The recent decline in the price for lead to 3½ cts., N. Y., which led to curtailment in production by the principal operators both in Missouri and Idaho, gave interest to the discussion of what is the average cost of producing lead in the United States. Bearing upon this subject, the following paragraphs from "Lead and Zinc in the United States," by W. R. Ingalls, published in 1908, are of interest:

"While the tariff wall inclosing the lead industry of the United States remained practically unchanged from 1864 to 1894, the conditions of production in the United States experienced great alterations. From 1871 to 1880, and in the early '80's, the bulk of the domestic lead production came from ores of comparatively high grade in lead and silver, which in spite of high mining and smelting expenses caused the cost per pound of lead to be relatively low, but the producers were handicapped by the long and costly railway carriage on their metal. In 1872 the cost of transporting bullion from Eureka to San Francisco was about 3 cts. per lb.; in 1874 it was about 1.6 cts. From Salt Lake to Omaha the cost was 1 ct. per lb. in 1871; from Salt Lake to Chicago, 1.4 cts. per lb. in 1872. In 1880 the cost from Leadville to New York was 1.75 cts. per lb. Until the latter part of the '80's the producers of the West were under such heavy handicaps of freight rates. Even at the present time, when freight rates have come down to extraordinarily low points—0.32 ct. from Pueblo and Denver, and 0.54 ct. from Salt Lake City to New York—the western producers suffer from their distance—2000 to 2500 miles—from the principal markets, the cost of carrying lead from Monterey, Mexico, to New York being only 0.2 ct. per lb. However, there has been a vast improvement in this respect from the conditions of 1870–1885.

"But in the meanwhile the ores of high grade in lead and silver have disappeared and it has come to pass that the bulk of the lead production of the United States is obtained from very low-grade ore. It is undeniable that the tariff on lead has raised the price which American consumers have had to pay. It is doubtless true that at certain periods the price has been maintained in this way at figures which have given unnecessary advantage to the producers. But on the other hand, it is evident from a study of the history of the industry that the increase in domestic lead production, which has not more than corresponded with the increase in domestic consumption, has been greatly stimulated by the advantage in price which the tariff has bestowed, and moreover, this has fostered not only the lead industry alone, but also the mining and smelting of ores containing the precious metals, which in the absence of an abundant supply of lead ore would have to be worked by less economical methods.

"It is dangerous to generalize the cost of producing lead for the whole country, or even for a particular district. In the case of southeastern Missouri this can be done with more safety than in any other, because there the only value of the ore is in its lead content, and the grade of the ore mined, conditions of occurrence, and methods of mining are rather uniform throughout the district. In 1882 the cost of pig lead delivered at St. Louis by the large producers was 3 to 3.5 cts. per lb.[2] In 1884 the *Engineering and Mining Journal* expressed the opinion[3] that if freights were better adjusted the majority of the producers of the United States could stand a price of 3.5 cts. or even 3.25 cts., but the pressure of lead at 2.75 cts. would be such that as

[1] From *Eng. Min. Jour.*, Dec. 19, 1914.
[2] *Min. Res. of U. S.*, 1882, p. 312.
[3] Feb. 2, 1884.

that figure was approached the number of idle mines would increase in geometrical ratio.

"In 1899 the cost to the principal producers of southeastern Missouri was 2.25 cts. per lb., delivered at St. Louis. However, none of the figures above given include interest on the money invested, return of the principal, etc.[1]

"In a previous chapter, it was estimated that the cost of producing lead in the Cœur d'Alene in 1907 was in the neighborhood of 3.3 to 3.5 cts. per lb., basis New York delivery, *i.e.*, if the price of lead should be 3.5 cts. per lb. and the price of silver 50 cts. per oz. at New York, some of the Cœur d'Alene large producers would realize no profit, even after disregarding allowances for amortization. It would be highly difficult to generalize the capital account in this district, but probably it would not be far out of the way to say that the total cost of producing lead in Cœur D'Alene is in the neighborhood of 4 cts. per lb. when silver is worth only 50 cts. per oz. Cœur D'Alene and southeastern Missouri together furnish nearly 60 per cent. of all the lead now produced in the United States. The actual cost of this lead has been about 3 cts. per lb. under most favorable conditions. The average cost of all the lead produced in the United States is probably considerably higher than that.

"There is no question that lead can be produced more cheaply in Mexico, Europe and Australia than in the United States, inasmuch as the price at London for long periods has been lower than 3 cts. per lb. and the output of the mines is maintained. The superior advantage of the foreign countries is partly in cheaper labor, partly higher grades of ore, which more frequently than in America yield two valuable products, *e.g.*, zinc and lead, as in Australia, and partly to shorter railway hauls. The cost of smelting and refining is as low in the United States as anywhere in the world; the freights on the whole are higher—not per ton mile, but in the aggregate of miles; the cost of mining per ton of concentrated product is doubtless higher on the whole."

[1] It is utterly misleading to draw conclusions from figures which do not take those factors into account. Producers who are already established may be willing for a time to sell their output at a price which returns only the direct cost, or even less, rather than incur the greater loss of suspending operations, but so long as such a condition exists no new capital will go into business where the adventurers can not see a return of the principal and a proper interest upon it. The purchase of an acreage of land sufficient to warrant development on a large scale, the sinking of shafts and equipment of plant a few years ago would cost about $1,000,000 for a productive capacity of 10,000 tons of pig lead per annum. Estimating amortization at 10 per cent. and interest at 5 per cent., the annual fixed charge would have been $150,000, or 0.75 ct. per lb. of lead. A total cost of production of 3 cts. per lb. basis, St. Louis, is probably the lowest on record for the southeastern Missouri lead. At present the cost is considerably higher. It is a fact that this lead has been sold at a lower price than 3 cts., but it has been at a loss, all charges considered.

Since the date of the last figures quoted above, conditions certainly have not changed for the worse among the lead producers. In 1912–1913 the cost of lead to the Bunker Hill & Sullivan, the leading Cœur d'Alene producer, was about 2.5 cts. per lb. The cost of the Federal Mining & Smelting Co. in 1913 was about 3¼ cts. per lb. There are no published data respecting the Hercules, Hecla, Stewart and other important producers, but their figures probably fall between 2½ and 3¼ cts., and more nearly the former than latter.

Although the average cost in Missouri is now somewhat higher than it was 10 to 15 years ago, it is not, probably, higher to any great degree. Such increase as there has been is ascribable to the mining of a lower grade of ore yielding less lead per ton, and to increased wage scale.

On the other hand, these adverse factors have been almost offset by improvements in mining, milling and metallurgical methods. It seems to be reasonably assured that the Missouri lead cost a little less on the average than the Idaho lead, and that neither the Missouri nor the Idaho producers would fail to meet direct operating expenses even if they should receive only 3 cts. per lb. for their product, but they would not have anything to make good the wear and tear of their plants and give them a reasonable profit on their invested capital unless they should receive at least consideraby more than 3.5 cts. per lb., which price must be uncomfortable to all but the very favorably situated producers. Their willingness to curtail when that figure was reached supports the conclusions herein drawn. Equally clear is it that the big producers must make a great deal of money when lead is at 4 cts. We can therefore understand why the lead miners maintained their enormous production until the screws were turned against them.

White Lead and Oxides in 1914[1]

Weather conditions over a large section of the country were unfavorable for painting during the winter and early spring months of 1914, and the result was that sales of all paints up to April 1 were considerably below normal. The later improvement, however, was sufficient to offset the early losses, and so far as lead pigments are concerned the year showed a fairly satisfactory aggregate movement. The general depression in business has had no marked effect upon white lead, but the demand for oxides from some of the large consuming industries has been curtailed by a falling off in the sales of their products.

Prices did not follow closely the fluctuations in pig lead, although the marked decline on the latter in September and October gave a weak tone to the whole line of lead products.

Business in dry white lead was on the basis established prior to the opening of the year, of 5¼ cts. to the largest buyers, until October, when a reduction of ¼ ct. was made, and this promises to be the base price for 1915, unless there should be some violent fluctuations in pig lead. Neither buyers nor sellers are disposed to enter into long-time contracts, but such contracts as are made for any period are on the 5-cent basis.

The price of white lead in oil was fixed in November, 1913, at 6¾ cts. to the largest buyers on all of the standard brands. This was a decline of ½ ct. from the highest prices of that year and was made following a break in pig lead and partly in anticipation of a further decline in the latter. This occurred later, but it had no effect upon white lead until the abnormally low figures were reached in October, when there were

[1] *Eng. Min. Jour.*, Jan. 9, 1915.

idences of a disposition on the part of corroders to reduce the margin tween their products and the metal, if there was any assurance of the tter remaining on its present low level. Their doubts upon this point ere confirmed, however, by an advance of $8 per ton in the price of pig ad between Nov. 12 and 20.

A slight reaction occurred later, but apparently manufacturers sitated to change the price of white lead in oil until there was some ore definite development in regard to the probable course of the metal arket.

PRODUCTION OF LEAD PIGMENTS IN THE UNITED STATES

ear.	Red Lead.		White Lead. (a)		Litharge.		Orange Mineral.	
	Short Tons	Value.	Short Tons.	Value.	Short Tons.	Value.	Short Tons.	Value.
9...	10,199	$1,070,895	103,466	$10,812,197	10,020	$1,032,060	928	$ 139,200
0...	10,098	1,050,192	96,408	9,910,742	10,462	1,067,124	825	100,650
1...	13,103	1,448,550	100,787	11,252,653	9,460	979,586	1,087	224,667
2...	11,669	1,262,712	114,658	11,978,172	12,755	1,299,443	867	138,349
3...	12,300	1,385,900	112,700	12,228,024	12,400	1,326,800	1,000	168,000
4...	13,938	1,672,569	126,336	13,896,913	12,487	1,248,691	1,125	168,681
5...	16,269	1,919,767	122,398	12,068,443	12,643	1,422,616	1,000	120,000
6...	13,693	1,874,448	123,640	15,234,990	13,816	1,890,050	2,927	421,488
7...	13,370	1,778,717	111,409	12,254,297	14,769	1,624,553	815	123,917
8...	11,358	1,156,282	116,628	10,515,315	12,254	1,231,206	393	43,157
9...	15,800	1,438,197	131,643	12,652,638	13,391	1,266,903	530	68,003
0 (b)	16,116	1,482,672	134,276	13,024,762	13,659	1,283,940	541	70,330
1 (b)	19,594	2,345,520	132,612	17,393,241	25,190	2,733,196	766	119,370
2 (b)	21,120	2,571,702	146,833	18,683,461	29,111	3,194,194	545	88,245
3 (b)	17,635	2,127,976	142,626	18,112,219	23,093	2,524,707	434	71,625

(a) The output of "sublimed white lead," a mixed sulphate and oxide of lead, is not included 1904–10. (b) U. S. Geol. Surv.

IMPORTS OF LEAD PIGMENTS INTO THE UNITED STATES

Year.	Red Lead.		White Lead.		Litharge.		Orange Mineral.	
	Pounds.	Value.	Pounds.	Value.	Pounds.	Value.	Pounds.	Value.
9.....	776,197	$30,479	583,409	$30,212	55,127	$3,614	1,141,387	$58,142
0.....	549,551	25,532	456,872	28,336	77,314	2,852	1,068,793	61,885
1.....	485,466	19,369	384,671	21,226	49,306	1,873	977,644	52,409
2.....	1,075,839	37,833	506,423	25,320	88,115	2,908	997,494	49,060
3.....	1,152,715	40,846	453,284	24,595	42,756	1,464	756,742	36,407
4.....	836,077	30,115	587,383	33,788	44,541	1,500	766,469	37,178
5.....	704,402	26,553	597,510	34,722	117,759	4,139	628,003	31,106
6.....	1,093,619	50,741	647,636	41,233	87,230	3,737	770,342	42,519
7.....	679,171	35,959	584,309	37,482	90,475	4,386	615,015	37,799
8.....	645,073	28,155	540,311	30,451	96,184	3,327	485,407	26,645
9.....	760,179	30,428	694,599	39,963	90,655	3,740	496,231	27,562
0.....	822,289	32,750	686,052	38,919	48,693	2,252	600,461	32,199
1.....	1,163,533	46,170	741,071	46,213	24,662	1,196	504,734	28,515
2.....	757,908	33,854	687,705	46,494	32,443	1,550	334,551	20,914
3.....	99,832	4,903	672,109	45,266	34,023	1,750	330,525	22,205
4.....	13,554	2,907	596,567	40,213	33,651	1,805	240,388	16,388

Prices on oxides have been sagging for the last 6 months, the earliest pression having come as much from the apparent probability of com- tition from abroad, which has been made possible by the new tariff, from the low price of pig lead here. Ordinary powdered litharge sold

early in the year at 5¼ cts. in a large way; later on 5 cts. was made the bottom figure, and at the close the range for large packages was 5 to 5¾ cts. according to quantity.

Red lead has sustained a more marked decline and is now quoted as low as 5½ cts. for the ordinary grades and up to 6¼ cts. for the high standards for structural or other special purposes The European war has removed any immediate danger of foreign competition, and while the present low prices are based chiefly on the cost of pig lead, they are also influenced by a diminished demand from the large consuming industries and an excessive domestic production.

The practical closing of European sources of supply has resulted in an increased demand for white lead and the oxides for export, not only to neutral countries, but also the belligerent nations which are unable to draw upon their usual sources. There is reason to hope that some of this trade will outlive the war, but manufacturers here do not feel confident of their ability to compete with foreign labor and other costs, under normal conditions.

Linseed oil has not reached extremes which have affected the price of lead in oil either way. To large consumers the price during the first half of the year was from 50 to 52 cts., with a considerable advance in July on the prospect of a short seed crop. This was more than offset by the subsequent depression, however, and the close is at about 46 cts.

Sanitary Conditions

There has been a constant improvement in sanitary conditions in the industries making lead products, due to increased precautions by the employers and more intelligent coöperation on the part of the employees. The states in which records are kept will probably all show fewer cases of lead poisoning each year. The work of educating employees to the necessity for personal care is as important and even more difficult than the installation of protective appliances or the adoption of protective rules. Now that occupational diseases come under the provisions of the Workmen's Compensation or Employer's Liability Acts of many of the states, employers are feeling more keenly than ever before the necessity for enforcing protective methods, while the same laws are calculated to make workmen a little more lax in their observance of rules adopted for their own protection. In some states the workman is made liable, under the sanitary laws, for failure to comply with all such rules, but in other cases the liability is all thrown upon the manufacturer.

Lead Mining in the United States

The following table shows the production of lead according to the source of the ore, as given by the U. S. Geological Survey. These

figures are of course considerably less, in most cases, than the mine production; wherever important differences occur, both figures will be given if they are available.

PRIMARY LEAD SMELTED OR REFINED IN THE UNITED STATES
(Apportioned according to source of ore)

	1906.	1907.	1908.	1909.	1910.	1911.	1912.	1913.	1914.
Domestic Ore:									
Alaska	8	.....	3	69	75	51	45	6	.....
Arizona	2,884	2,418	1,464	1,507	948	3,428	3,891	4,901	5,602
Arkansas	.....	15	.....	14	.....	15	.....	.....	52
California	432	938	515	977	1,207	615	811	3,294	3,698
Colorado	50,497	52,552	28,729	30,865	38,542	30,442	37,039	42,840	41,198
Idaho	117,117	123,292	98,464	103,747	109,951	117,335	127,780	137,802	177,827
Illinois	572	498	362	273	263	308	513	619	427
Iowa	270	225	110	15	.....	.....	.....	.....	34
Kansas	1,932	1,798	2,293	2,763	1,308	2,522	1,937	1,504	1,043
Kentucky	44	75	.....	.....	50	.....	91	16	16
Missouri	111,075	122,856	122,451	141,105	161,659	182,203	162,610	152,430	194,275
Montana	2,485	2,145	2,320	1,451	1,943	2,484	2,517	3,256	4,386
Nevada	1,669	3,480	3,796	4,792	2,246	1,082	5,699	6,142	5,996
New Mexico	640	2,047	586	1,350	1,890	1,371	2,511	1,821	741
North Carolina	.....	.....	.....	.....	2	35	34	10	.....
Oklahoma	.....	404	1,409	2,268	1,805	1,925	2,500	3,214	3,916
Oregon	.....	5	7	7	.....	11	21	37	17
South Dakota	.....	.....	13	.....	8	33	12	7	2
Tennessee	11	16	.....	.....	.....	.....	.....	.....	.....
Texas	25	12	42	44	36	57	30	108	89
Utah	56,260	55,540	42,455	66,648	60,605	54,933	60,664	71,069	88,976
Virginia	.....	83	13	.....	87	400	85	878	143
Washington	46	341	391	120	339	612	53	9	2
Wisconsin	1,753	3,573	4,013	3,252	3,909	3,966	3,301	2,639	1,818
Undistributed	380	896	36	317	101	48	120	63	99
Zinc residues	2,053	1,890	1 290	1,735	2,237	1,987	3,131	3,765	4,125
Total from domestic ore.	350,153	375,099	310,762	363,319	389,211	405,863	415,395	436,430	534,982
Foreign Ore:									
Africa	.....	288	.....	3,150	3,310	582	1,774	5,976	2,942
Canada	7,238	2,607	162	66	25	122	29	16	2
Central America	112	23	12	20	3	28	.....	.....	.....
Mexico	21,435	20,204	10,145	16,944	11,704	7,333	7,407	4,512	2,386
South America	.....	919	1,186	1,536	2,996	2,677	2,332	2,617	1,821
Other foreign	18	.....	4	38	27	22	30	102	488
Foreign Base Bullion:									
Canada	.....	2,716	179	1,500	.....	.....	.....	.....	.....
Mexico	39,743	34,251	73,210	70,816	76,805	84,220	76,805	37,359	21,689
Total from foreign ore and base bullion.	68,546	61,008	84,898	94,070	94,870	94,984	88,377	50,582	29,328
Grand total, derived from all sources.	418,699	436,107	395,660	457,389	484,081	500,847	503,772	487,012	563,810

Arizona.—Lead production in Arizona in 1914 amounted to 5602 tons, an increase of 701 tons over 1913, as compared last year with an increase of 1010 tons over 1912. The production comes largely from Bisbee.

Arkansas.—Arkansas again enters the field of small producers, with 52 tons in 1914, after having been without production for 2 years.

California—California, while not a large producer of lead, is gradually moving up among the small producers. 1914 shows a production of 3698 tons, against 3294 tons in 1913 and 811 tons in 1912.

Most of the lead produced has come from the Cerro Gordo, Darwin,

and Modoc districts, all in Inyo County, in the eastern part of the state. The Cerro Gordo district has furnished by far the largest output, having yielded during its most prosperous years $7,000,000 in silver-bearing lead.

The Darwin district has probably produced between $2,000,000 and $3,000,000, according to the U. S. Geological Survey. Darwin, the principal settlement of the district, is situated 24 miles southeast of Keeler on Owens Lake, the southern terminus of the Nevada & California Railroad. In the early part of the decade, between 1870 and 1880, silver-bearing lead ores were discovered in the vicinity of Darwin. A town soon sprang up here, and it is said to have had at one time a population of several thousand inhabitants. Three smelters were built in 1876 and a heavy production of base bullion was made. These furnaces, after the activities of the first few years, were operated in a desultory way only. Mining and smelting expenses were high, because prior to the completion of the railroad to Keeler in 1883 all freight had to be brought across the desert by teams from Los Angeles, a distance of 275 miles. The richer and more easily mined ore-bodies were early exhausted, and the district soon lapsed into stagnation, occasionally interrupted by periods of activity.

In the early part of 1912 interest in the district was renewed and considerable activity was displayed. It is locally hoped that the introduction of modern machinery and the systematic exploration work now being undertaken at some of the old mines will cause a permanent revival of the mining industry.

The ores consist of silver-bearing galena, together with minor pyrite and zinc blende, commonly associated with a gangue of calcite and fluorite. As a rule the galena is considerably oxidized to lead carbonate and sulphate. There is, however, no evidence of important downward concentration of silver, lead, or zinc through the action of oxidizing solutions, as, indeed, appears unlikely from the prevalence of calcite in the deposits. From this it follows that the value of surface ore is an index of the probable value of ore masses found during deeper exploration.

Colorado.—Lead production in Colorado in 1914 amounted to 41,198 tons, a decrease of 1642 tons from 1913.

Deposits of cerussite or lead carbonate near Ilse, in the northeastern part of Custer County, Colorado, were examined by J. F. Hunter of the U. S. Geological Survey.

The deposits extend in a narrow belt for several miles along the foot of the steep western slopes of the Wet Mountains, where faulting and crushing have produced conditions favorable to ore deposition. The lead carbonate has been deposited in zones or shoots, filling joint planes

and cracks in crushed and altered granite. Investigations show that the carbonate ores have probably resulted from the oxidation of galena, which should be found at greater depths than have yet been attained by mining or drilling. Only the upper portion of the ore deposits, known as the oxidized zone, has been opened.

LEAD PRODUCTION OF COLORADO (a)
(In tons of 2000 lb.)

County.	1906.	1907.	1908.	1909.	1910.	1911.	1912.	1913.	1914.
Clear Creek..	1,439	1,832	1,205	1,495	1,228	1,956	2,423	2,160	.....
Hinsdale.....	442	470	82	50	124	60	611	410	.....
Lake.....	23,918	17,032	7,169	7,061	6,364	8,119	12,368	14,000	.....
Mineral.....	7,443	6,490	4,119	4,526	4,066	3,501	2,634	1,780	.....
Ouray.....	2,861	1,803	1,516	1,354	2,021	2,002	1,531	1,200	.....
Pitkin.....	8,781	6,957	3,713	6,315	6,704	5,090	4,195	8,390	.....
San Juan	2,070	6,213	5,133	4,921	5,444	3,140	4,452	14,900	.....
Others.....	6,038	5,696	5,918	6,638	3,332	8,891	8,475		.....
Total.....	52,992	46,493	28,855	32,360	29,283	32,759	36,689	42,840	41,198

(a) As reported by the State Commissioner of Mines.

Two important ore zones, one at the Terrible mine and the other at Lead Hill, on the Wild Girl and High Kicker claims, were visited; and a trip was made over Lead Hill into Parker Gulch, revealing considerable cerussite strewn over the hills as float, so that the existence of additional bodies and zones of cerussite seems probable.

The mines of this district have been worked intermittently since 1884 and have produced nearly $1,000,000 worth of lead. It is reported that the ores averaged from 5 to 8 per cent. of lead and were capable of being concentrated to a product running from 60 to 70 per cent. The ores thus far mined contain a small amount of silver but no zinc, arsenic, antimony, or sulphur.

Idaho.[1]—In Bonner County, up near the British line, the Idaho-Continental mine has developed 100,000 tons of high-grade lead-sulphide ore, carrying excellent values in silver.

In Custer County the Red Bird Mining & Smelting Co. operated its small smeltery for about a month and produced 2700 bars of bullion containing about 80 oz. of silver per ton. The Red Bird mine has been further developed during the year and now shows a supply of relatively high-grade silver-lead ore aggregating about 100,000 tons, with an average value of about 20 oz. silver and 20 per cent. lead.

In the same region there are a number of promising lead-silver and siliceous ore deposits that will doubtless be heard from when better transportation facilities are afforded. In the same county, at Mackay, the Empire Copper Co. made its normal production until the war intervened. The usual strong force of lessors has been maintained. A lower tunnel,

[1] Robert N. Bell, *Eng. Min. Jour.*, Jan. 9, 1915.

to be 4000 ft. long, is being pushed, which will undercut its present workings 1000 ft. deeper, and this should reach the ore within a few months. The company is contemplating the erection of a Christensen process mill to handle its extensive reserves of low-grade ore.

The Wilbert mine and mill, in Fremont County, were operated during part of the year and made a production of over 3,000,000 lb. of lead, but were forced to suspend milling by reason of the low prices and the fact that while the resources are relatively high in lead, they have always been low in silver.

In the principal lead-silver mines of the Gilmore district of Lemhi County, the year's shipments of mineral are considerably lower than those of 1913. A good output was made from the Latest Out mine, under the management of the principal owner, Ralph Nichols, and the property is looking its best at the bottom, a depth of 600 ft. A small development force was carried on the adjoining Pittsburgh-Idaho mine.

The adjoining Allie and Gilmore companies have developed several parallel lead-silver veins through a 3000-ft. working tunnel during the year, and are meeting with encouraging results. One of these veins, parallel to the lead deposits, carries a long shoot of earthy-brown iron ore, containing average values of $15 per ton in gold with only traces of lead and silver, and considerable of it was shipped during the year.

The Cœur d'Alene[1] lead, silver, zinc, and copper district of Shoshone County, Idaho, as a whole undoubtedly suffered less from disturbed conditions during the latter part of 1914 than any other base-metal mining field in the Northwest or in British Columbia. The mines at Mullan, two of them copper producers, had to close early in the fall, but all the other producers of the district continued, some, however, on a more or less restricted production. So that while profits were badly cut into by the soft metal markets, industrial conditions, while not good during the latter half of 1914, were better than in nearly all other neighboring districts.

New production and ore development have come from the important operations of the Consolidated Interstate-Callahan, Tamarack and Custer Consolidated in the Sunset and Nine Mile country, and the Caledonia Mining Co. in the Wardner field, the last beginning a splendid production in June because of the completion of arrangements for milling and transportation through the Kellogg tunnel, former production having come solely from shipments of high-grade crude ore and the products of close sorting and hand jigging.

The treatment of slimes from the concentrators of the district for the recovery of the lead, silver, and zinc formerly wasted has continued to

[1] S. A. Easton, *Eng. Min. Jour.*, Jan. 9, 1915.

receive systematic study, and carefully organized investigation by all the producing companies and the results secured by flotation and its adaptations to the conditions to be met here are a notable metallurgical achievement. The Bunker Hill & Sullivan company has supplemented these improved wet concentration methods by further electrochemical work, both on a laboratory and on a working scale, designed to produce metallic lead, silver and zinc, or the salts of these metals. The results are not yet conclusive, but are a distinct new development and of much interest and promise.

Deep development in all the older mines continues favorable and the new production and development noted above from virgin ground assures the importance of the Cœur d'Alenes as a producing field for the immediate future and probably for very many years to come.

The total production for the year amounted to 177,827 tons of lead, against 137,802 tons in 1913.

Illinois.—Lead production in Illinois decreased from 619 tons in 1913 to 427 tons in 1914.

Iowa.—Iowa, another of the intermittent producers, appears in 1914 with 34 tons, after 4 years' absence from the list of producers.

Kansas.—Production in Kansas amounted to 1043 tons, compared with 1504 tons in 1913. All the mines in the Badger-Peacock district were idle, and the production of the Galena district was less in 1914 than in 1913. The Lawton district was very active; several new concentrating plants were in operation, and the mine output was about double that of 1913. The total quantity of galena concentrates marketed from Kansas in 1914 was 1808 tons, valued at $79,976, compared with 3102 tons, valued at $158,019, in 1913. This decrease was due entirely to a decline in production from the Galena district and particularly in the yield from "sheet ground." Decreased mining in "sheet ground" also resulted in increasing the average percentage of concentrates contained in crude ore from 4 per cent. in 1913 to 4.37 per cent. in 1914.

Kentucky.—The mine production of both lead and zinc in Kentucky was less in 1914 than in 1913. The shipments of galena concentrates were 26 tons, valued at $800, in 1914, compared with 40 tons, valued at $1422, in 1913. As the galena is derived in small quantities from the fluorspar mined, it is frequently held until carload lots are available for shipment, so that the sales in any one year may not represent the quantity of galena recovered in that year. No recovery of silver was reported from the treatment of lead concentrates in 1914.

The lead production for the state is estimated at 16 tons.

Missouri.[1]—The southeastern or disseminated-lead district of Missouri

[1] H. A. Wheeler, *Eng. Min. Jour.*, Jan. 9, 1915.

produced 163,000 tons of lead in 1914. This is a new high record and re-establishes the consistent growth that this premier lead camp has shown for many years and which was only interrupted in 1913 as the result of a strike. The 1914 output exceeds that of 1913 by about 26,000 tons and that of 1912, the prior record output, by 16,000 tons, or about 10 per cent.

That the 1914 output should show an important increase is especially noteworthy, as the leading producers curtailed their output 20 to 25 per cent. during the last quarter of the year on account of the severe depression, while no new mines were opened—in fact, fewer shafts than usual were operated. This growth is mainly due to improved operating efficiency, in which the flotation process has been an important factor. The district has just passed through the most trying year in its history as regards profits, as the lead market was abnormally depressed, especially in the latter half of the year, while labor was paid the highest rates that ever ruled in this district. These conditions had a highly stimulating effect in improving the working efficiency, one of the results of which was that lower grade ores were being worked than ever before. The lack of walls or defined limits to the disseminated ore-bodies has always imposed a big responsibility on the mining captain as to when to cease mining, as the ore gradually dies out in the surrounding dolomite, and it is largely a matter of experience and conditions as to where to draw the line between pay ore and rock that is too low grade. With the improved operating efficiency, many abandoned stopes are being successfully reworked, in spite of the low-grade tenor of the ore, and the average lead yield of the ore now being mined probably approximates 3 per cent., as compared with former averages of 3.4 to 4 per cent. While all the mines have runs or shoots that assay from 5 to 15 per cent., there is now such a large amount of ore being extracted that will yield about 2 per cent. that the average of the district may be estimated at 3 per cent. lead, after deducting milling and smelter losses.

An important feature of 1914 was the successful introduction of the flotation process, which has now been adopted by all the larger producers. While there is considerable variation in the recovery at the different mills, they are all effecting a marked saving from the slimes that hitherto have been largely or entirely lost. The process was introduced at the Federal mill under the guidance of H. A. Guess, the concentration specialist, and subsequently adopted and modified by the other companies. Oil of creosote is employed as the selective medium, and the concentrates assay about 50 per cent. lead after drying.

The labor situation, aside from being at maximum wages, was otherwise satisfactory during 1914, as it was plentiful and much more efficient.

Many of the outlying shafts were closed down and the ore tonnage maintained by concentrating at the more central mines. This resulted in many of the men being laid off, with resulting increase in the efficiency of those remaining at work besides the ability to weed out the "lame ducks." As wages were forced up about 10 per cent. by the strike of 1913, it is quite likely that they will be reduced at least that much this winter.

The depressed condition of the lead market caused a total cessation of prospecting and only a few diamond drills were operated to maintain the development of the present ore-bodies. Even the important discovery of disseminated lead near Potosi, in Washington County, made at the close of 1913, was not followed up by the local parties who did the drilling, although it is said that they have materially increased their acreage.

The output of "shallow lead" from the innumerable "diggings" in Washington, Jefferson, and Franklin Counties, which adjoin St. Francois County on the west and north, was almost negligible, as "gophering" is only active under the stimulus of good prices.

Over 95 per cent. of last year's output was produced by five companies in St. Francois County, which still retains its paramount importance as the main producer of the disseminated lead belt (as also of Missouri). There are several other small companies that are in the prospecting stage, but they did not attempt any development work last year.

The year 1914 was one of the most eventful in the history of the St. Joseph Lead Co., and its close finds it in a stronger, healthier, more promising condition than for a long time. The internal storms that started the previous year resulted in many salutary changes, not the least important of which was complete reorganization in the technical department that resulted in greatly improved efficiency. The closely affiliated Doe Run Lead Co. was taken over and absorbed by the St. Joe company on a stock basis, which now makes this company by far the largest lead-producing unit in the country, while marked economies resulted from the consolidation.

Most of the outlying shafts of the St. Joe were shut down, and mining has been concentrated at old No. 1 shaft at Bonne Terre and at the Leadwood shaft. As the old mill is at the former and the new 2000-ton mill at the latter, this has dispensed with the ore trains, besides temporarily annulling the small outlying mining units. Similarly, the mining has been concentrated in the Doe Run department to three shafts, all of which are close to the new mill.

The old mill at Bonne Terre has again been remodeled and equipped with Hancock jigs, while the "chats" or tailings are now loaded mechan-

ically. With its new flotation equipment, this veteran mill would no longer be recognized by its design, so completely has it been altered. It was built in 1883 as a 500-ton unit on lines that were unique and largely evolved from local ideas and experience. At that time it was the largest concentrator in the country outside of the Lake copper mills, and with its Parson jigs and Parson-Rittinger side-bump tables, it was a great success from the start. It. has been enlarged and remodeled several times since then, and to-day it is a modern 1500-ton mill in its equipment, although greatly handicapped by a building that was designed for a radically different system of concentration.

The new Doe Run mill has been enlarged to 4000 tons daily capacity and now treats the output from all the Doe Run mines, as the two older mills have been abandoned. At the smelting works at Herculaneum, the extensive series of dust chambers and bag house were completed and are in successful operation, after being delayed by a fire. Part of the output will be desilverized this year and put on the market as a corroding "lead," for which it is admirably adapted, as it is free from bismuth.

The Federal Lead Co. continues to be a large producer, being only exceeded by the new combined output of the former St. Joseph and Doe Run companies. Since the introduction of the flotation process for treating the slimes, the canvas tables that were formerly employed have been abandoned. The central power plant has been increased by three new boilers that are equipped with chain grates, and an 800-kw. Allis-Chalmers horizontal turbine. This enables the pumping at Nos. 4 and 7 mines to be done with electric pumps, and three triplex Aldrich pumps have been installed at No. 7 shaft that have an individual capacity of 1250 gal. per min. An interesting test was made last year with a mechanical mine shoveler that was operated by electricity, to try to reduce the high cost of hand shoveling. With its high maintenance cost, large percentage of time lost by delays, and the relatively small size of the stopes and consequently limited tonnage, it did not prove a financial success. It was an important pioneer test, and after the machine has been remodeled it has much promise where the conditions are favorable.

The Desloge Lead Co. operated its mining and milling departments to full capacity until the latter part of 1914, when the output was reduced about 20 per cent. to meet the depression. The flotation process was successfully introduced, and an important recovery was effected from the slimes that had hitherto been lost. The new mine, No. 6, at Leadwood, was drowned out for about a month by the record-breaking cloudburst that did so much damage throughout the district last October.

The National Lead Co. had an active year, as in addition to its own ouput it is milling and smelting the "Jake Day" ore from the St. Fran-

cois Lead Co. The flotation process was added to the slime department, with an important recovery of clear milling ore beside the "floated lead." The lease on the extensive Mine la Motte estate was surrendered and its operation was taken over by another company.

The St. Francois Lead Co., which purchased the frequently condemned Jake Day land, had a successful year, as the ore averaged unusually high, while the increased development augmented the tonnage. Daily mill samples assayed from 7 to 12 per cent. and averaged over 9 per cent. This company has not yet been provided with a mill, and its ore is being milled and smelted by the National Lead Co., after being hauled about 12 miles over the Missouri River and Bonne Terre Railroad.

Madison County.—Madison County, which adjoins St. Francois on the south, had only one active producer last year, the famous old Mine la Motte property, which turned out more lead than usual under a lease by a new operating company.

The North American mine, at Fredericktown, is still closed down. When last operated, all the metals—lead, copper, nickel, and cobalt—were recovered as sulphides. They are said to have aggregated 6 per cent. in metal content and were worked into marketable products on the premises. The lead and copper predominated and as much as 5 tons *per diem* of ingot copper was produced. The Catherine mine, as also the adjoining Fleming property, has not been operated since the Federal Lead Co. surrendered its lease on same last year.

Montana.—Another of the smaller producers that is making a notable increase in production is Montana. For a number of years the production varied 300 or 400 tons on either side of the 2000 mark. In 1912 the production reached 2517 tons; in 1913 it increased to 3256 tons and in 1914 to 4386 tons.

Butte & Superior produced 4000 tons of lead concentrate assaying 45.6 per cent. lead.

Nevada.—Lead production in Nevada suffered a slight decline in 1914, amounting to 5996 tons, as compared with 6142 tons in 1913 and 5699 tons in 1912.

The Yellow Pine Mining Co. operated at about two-thirds capacity, producing 2200 tons of lead concentrates.

New Mexico.—Lead production in New Mexico is on the decline. The 1912 production of 2511 tons dropped to 1821 tons in 1913, and 1914 returns show only 741 tons.

Oklahoma.—Oklahoma was the only one of the Central States which showed a larger output of lead in 1914 than in 1913—3916 tons, against 3214 last year. The increased yield in 1914 was due entirely to operations in the Miami field, as few of the mines in the Quapaw and Peoria

districts were operated. The output of lead concentrates from these districts decreased about 100 tons.

The shipments of galena concentrates from the Miami district increased from 7710 tons in 1913 to 9401 tons in 1914, and the shipments of sphalerite from 23,018 tons to 28,219 tons. A considerable part of the 1914 yield was derived from mines southeast and northeast of the mines first developed in the camp. Several new concentrating plants were in operation and others are being erected. Notwithstanding the low prices of lead and lead ore, development work and prospecting were more active than in any other part of the Central States and conditions are favorable for an increased mine output in 1915.

Oregon.—Production in 1914 is placed at 17 tons, against 37 tons in 1913.

Texas.—Production accredited to Texas amounts to 89 tons, against 108 tons in 1913 and 30 tons in 1912.

Utah.—The Silver King Coalition, Daly-Judge, and Silver King Consolidated, at Park City, producing silver-lead ores, and the Utah Apex, Bingham-New Haven, United States properties, and Utah Consolidated, at Bingham, producing lead-silver ores, were the principal shippers. The Daly West rebuilt its mill and installed a new hoist. The Silver King Coalition built and equipped a large underground station on the Alliance tunnel level to carry on work at depth. The Daly-Judge put in an experimental Callow flotation plant in its mill to treat tailings. The Snake Creek drain and operating tunnel, which is being driven by the Daly-Judge, was advanced 3850 ft. during the year, leaving less than 4000 ft. still to be driven. On Dec. 2, the length was 10,152 ft. The Silver King Consolidated opened a large new ore-body and installed machinery. The Utah Apex remodeled and enlarged its mill. The Centennial-Eureka, Chief Consolidated, Iron Blossom and Gemini, in Tintic, produced siliceous ores and lead ores.[1]

The lead production of the state showed an increase from 71,069 tons in 1913 to 88,976 tons in 1914. This increase of 17,907 tons is exceeded by the 42,000-ton increase in Missouri and by the 40,000-ton increase in Idaho, but the percentage increase for Utah is greater than either of the others, amounting to almost 40 per cent.

Virginia.—Lead production in Virginia has been somewhat erratic during recent years, amounting to 85 tons in 1912, 878 tons in 1913, and 143 tons in 1914.

Wisconsin.—The production of lead in Wisconsin has been undergoing a steady decline since 1911, the production then amounting to 3966 tons, while in 1914 it amounted to only 1818 tons.

[1] E. R. Zalinski, *Eng. Min. Jour.*, Jan. 9, 1915.

LEAD PRODUCTION OF THE WORLD
(In metric tons)

Year.	Australasia. (a)	Austria. (a)	Belgium. (a)	Canada. (a)	France. (a)	Germany (a)	Greece. (a)	Hungary (a)	Italy. (a)
1900 ..	87,100	10,650	16,365	28,648	15,210	121,513	16,396	2,030	23,673
1901 ..	90,000	10,161	18,760	23,537	21,000	123,098	17,644	2,029	25,796
1902 ..	90,000	11,264	19,504	10,411	18,817	140,331	14,048	2,243	26,494
1903 ..	106,006	12,162	22,263	8,226	23,258	145,319	12,361	2,057	22,126
1904 ..	117,895	12,645	23,470	17,241	18,800	137,580	15,186	2,104	23,475
1905 ..	106,418	12,968	22,885	25,391	24,100	152,590	13,729	2,146	19,097
1906 ..	93,557	14,846	23,765	24,580	25,614	150,741	12,308	1,925	21,268
1907 ..	96,608	13,598	27,450	21,660	24,800	164,079	13,814	1,468	22,978
1908 ..	119,207	12,669	35,650	19,593	26,112	164,079	15,892	1,544	26,003
1909 ..	77,992	12,941	40,306	23,295	26,927	167,920	14,948	1,590	22,133
1910 ..	105,897	15,476	40,715	14,967	20,226	159,851	16,710	2,077	14,495
1911 ..	105,397	18,097	44,308	10,791	23,635	161,287	14,234	1,583	16,684
1912 .	113,710	19,993	54,940	16,226	31,080	192,618	14,498	1,605	21,450
1913 ..	(d)116,000	22,312	35,750	17,089	(d) 28,000	d 181,100	(d) 18,400	(e)1,790	(d) 21,700

Year.	Japan. (a)	Mexico. (a)	Russia. (a)	Spain. (a)	Sweden. (a)	United Kingdom. (a)		United States.	Totals. (f)
						Foreign Ores.	Domestic Ore.		
1900 .	1,877	63,827	221	172,530	1,424	10,738	24,762	253,204	849,168
1901 .	1,806	94,194	156	169,294	988	19,639	20,361	253,944	892,407
1902 .	1,644	106,805	225	177,560	842	9,113	17,987	254,682	901,970
1903 .	1,728	(b) 94,181	106	175,109	678	14,900	20,278	256,138	916,896
1904 .	1,803	(e) 95,010	90	185,862	589	6,888	20,155	278,634	957,427
1905 .	2,272	(b)101,196	700	185,693	576	7,517	20,977	290,472	988,727
1906 .	4,305	(b) 73,699	907	185,470	753	6,984	22,691	323,567	986,980
1907 .	3,067	(b) 76,158	520	(d)185,800	813	10,880	24,850	322,854	1,011,397
1908 .	2,910	(b)127,010	523	188,062	277	11,480	21,336	284,858	1,057,205
1909 .	3,429	(b)118,186	(d) 790	179,993	166	8,056	22,822	(g)334,832	1,056,326
1910 .	3,907	(b)120,662	(d)1,200	190,523	355	8,933	21,866	(g)355,183	1,093,043
1911 .	4,160	(b)124,605	(d)1,000	189,810	1,134	10,048	18,278	(g)363,829	1,108,880
1912 .	3,613	(b)109,717	(e)1,000	232,612	1,073	(e) 8,255	17,806	(g)372,056	1,212,252
1913 .	(d) 3,600	(b) 55,530	(e)1,000	(d)203,000	1,235	(d)30,500	.....	(g)395,358	1,142,264

(a) From official reports of countries unless otherwise denoted. (b) Exports. (d) As reported by Metallgesellschaft, Frankfurt am Main. (e) Estimated. (f) The totals may be high on account of duplications which cannot be eliminated. (g) From *Eng. Min. Jour.*

Lead in Foreign Countries

War has exercised a different effect on the lead market from what it has done in the case of spelter in proportion to the different constitution of the industry. Germany, Austria, and Belgium normally consume more lead than they produce. Their joint production in 1913 was about 255,000 tons, and their consumption about 300,000 tons. On the other hand, while production in Spain and Australia was severely affected at the outbreak of war, a resumption of production on a considerable scale is now operating, and consequently the world's markets are not so entirely dependent on the position in the United States as is the case with spelter. No exact figures of output are available either from Australia or Spain since the beginning of the war. Very roughly, however, it is computed that the Spanish industry is now working at about three-quarters of its normal capacity, or say 15,000 tons a year, while the arrangements made

with the Proprietary and otherwise for the reduction of the lead ores at Broken Hill may give a yield of about one-half the normal, or say 60,000 tons, in all a little over 200,000 tons for the year. Mexico is also in shape to produce more largely, owing to the resumption of work at the plants of the American Smelting and Refining and Peñoles companies not long since. The output at present is estimated at about 6000 tons a month, or say 70,000 tons a year. As the American market is very heavily stocked, it may be assumed that the whole of this supply will be available for exports, whereas little or nothing reached England direct from Mexico last year, and the total shipments from United States ports of foreign lead refined in bond was only 21,193 short tons. Naturally the future course of events in Mexico can not be predicted, but as all factions now want money there is a disposition to try and keep the mines going, for if conditions are made too bad for them the last resort of the tax collector is gone. Indications are that the United States should be able to furnish whatever supplies are necessary to make up the deficiency caused by diminished operation in Spain, Australia, North Africa or elsewhere, and as American prices are low and production ample we may expect London prices to tend more and more to a parity with those ruling in America, and the expectation there for the present appears to be for a continuation of low prices.[1]

Belgium.[2]—Belgian imports of lead for the first 6 months of 1914 amounted to 31,839 metric tons, as compared with 35,828 metric tons for the corresponding period of 1913. The total imports for 1913 amounted to 67,052 metric tons, as compared with 67,903 tons in 1912. The exports for the first 6 months amounted to 41,496 metric tons, as compared with 38,471 tons for the corresponding period of 1913. The exports for the full year for 1913 amounted to 80,073, as compared with 74,238 tons in 1912. Further returns for 1914 were not available on account of the war.

Canada.[3]—The smelter production of lead from Canadian ores in 1914 was 36,337,765 lb. which, valued at 4.479 cts. per lb., the average price of pig lead in Montreal for the year, would be worth $1,627,568. The production in 1913 was 37,662,703 lb. valued at $1,754,705. With the exception of a small tonnage from the Yukon, the 1914 production was entirely from British Columbia ores, and was almost all recovered at the Trail smelter.

The exports of lead in ore, etc., in 1914 are reported as 246,100 lb., valued at $2681 and of pig lead 510,573 lb., valued at $19,507.

The total value of the imports of lead and lead products in 1914

[1] *Min. Jour.*, Jan. 30, 1915.
[2] Statistics of Julius Matton.
[3] From Preliminary Report on the Mineral Production of Canada for 1914, Canada Dept. of Mines.

1,042,538 and included old scrap and pig lead, 15,444,100 lb., at $590,557, manufactured lead 3,394,930 lb., valued at $186,165, actures n.o.p., $99,285, and litharge and lead pigments $166,531. ıports of litharge and pigment would contain approximately 1449 metallic lead and the total imports of metallic lead would there- ceed 10,869 tons.

ina (By T. T. Read).—The most important lead mine in China Shui Kou-shan, in Hunan province. The mine[1] has modern equip- out is operated only by Chinese who sell mostly to Carlowitz & f Hankow, who ship the concentrate to Europe. The value of tput of this mine is estimated at $600,000 per year. Up to the November, 3600 tons of lead ore and 125 tons of pig lead had been d from Changsha. There are other producing lead mines in China ere is no means of ascertaining their output.

nce.[2]—Imports of lead into France for the first 8 months of ted to 49,369 metric tons, as compared with 62,043 tons for the onding period of 1913. The total imports for 1913 amounted 52 tons, as compared with 88,871 tons in 1912. The exports for st 8 months of 1914 amounted to 6567 metric tons, as compared 629 tons for the corresponding period of 1913. The exports for l year of 1913 amounted to 11,899 tons, as compared with 15,476 or 1912. Further returns were not available on account of the

many.[2]—Imports of lead in Germany for the first 6 months of mounted to 28,826 metric tons, as compared with 41,438 tons for rresponding period of 1913. The total imports for the year 1913 ted to 83,781 tons, as compared with 93,585 tons in 1912. The s for the first 6 months of 1914 amounted to 18,199 metric tons, as red with 24,253 tons for the corresponding period of 1913. The xports for 1913 amounted to 41,369 tons, as compared with 38,115 n 1912. Further returns were not available on account of the

at Britain.[2]—The following table gives the imports of lead into d from the principal exporting countries for the last 3 years:

	1912.	1913.	1914.
.....	75,466	77,596	92,145
.....	60,292	72,252	68,519
tates.....	28,279	24,155	31,048
.....	17,757	10,380	1,735

Sci. Press, June 12, 1915.
stics of Julius Matton.
)

Russia.—Owing to military operations, there is a great demand for lead in Russia. Although the deposits of lead ore on the western shore of Murman, which is on the White sea, east of Varangerfiord, were discovered many years ago, and investigated to some extent by many Russians, including Kamensky in 1875 and Bartanoff in 1889, and again by Povalishin in the nineties, lead mining has not progressed. In the summer of 1903 the right to exploit the mineral was obtained by Nikolaieff; but he did not take advantage of the permission. This deposit required a geological investigation and the expenditure of a considerable sum of money in order to test its value. In 1905 new lodes were discovered, and the examination was in charge of an officer named Stefanovich and a merchant, Edward Ostrem, from the town of Abo. Their work showed the importance of the deposits, and at the present time negotiations are being carried on to organize a company to start proper development. Recently these engineers completed preliminary prospecting and discovered 50 new lodes, of which about 40 are within the area at their disposition. They have rights over 13 areas or lots, of which four are to be worked. In the autumn of 1914 a certain quantity of lead ore was delivered at Archangel, in which town it is proposed to carry on smelting operations.[1]

Spain.—The most important lead districts of Spain are in the provinces of Jaen, Murcia, Almeria, Cordoba, and Cuidad Real. Most of the ore is smelted in the country at the important establishments of Peñarroya, Cartagena, Linares, and Puertollano, the lead being shipped for refining pricipally to Belgium, a part, however, going to England. At the outbreak of the war the smelting establishments were obliged to close down, not only on account of the uncertainties of the market, of shipping facilities, and of the difficulties of transferring funds from one country to another, but because being in the hands of foreign companies, and their superior employees being foreigners, in nearly every case the commercial and technical heads of the business had to leave at short notice to take up their military duties, and in their absence the business could not be carried on. In the case of the Peñarroya Company, for instance, which owns both the largest colliery business and the largest lead-smelting business in Spain, no less than 150 employees, heads of departments, engineers, chemists, commercial and technical assistants of all kinds, left suddenly for France when war broke out, and the greater part of the business had to stop except as regards the output of coal for railway and other local consumption, throwing out of work directly and indirectly many thousands of work-people.[2]

The exports of lead from Spain for the first 10 months of 1914,

[1] *Min. Sci. Press*, Jan. 30, 1915.
[2] *Min. Mag.*, Nov., 1914.

amounted to 107,527 metric tons of soft lead and 19,835 metric tons of argentiferous lead, as compared with 148,481 tons and 27,166 tons for the correspondng period of 1913. The total exports for 1913 amounted to 171,894 metric tons of soft lead and 30,689 metric tons of argentiferous lead, as compared with 144,797 tons and 41,492 tons in 1912.[1]

Recent Improvements in Lead Smelting

By H. O. Hofman

Introductory; Physical Properties; Alloys; Compounds

Corrosion of Lead.—A Scala[2] shows that the solubility of lead in distilled water is not appreciably influenced by connecting it with zinc, tin or copper to form a galvanic couple. W. Vaubel[3] finds that the corrosion of lead by lime in contact with air is caused by the formation of lime peroxide. H. Heap[4] investigated the corroding effects of different waters. Distilled water with the exclusion of air shows little action, the presence of oxygen hastens corrosion, and that of oxygen and carbon dioxide greatly accelerates it. Corrosion increases up to 60° and then falls off; it is not greater at 100° than at 5°. Phosphates neutralize all corrosion, carbonates have a protective effect; nitrates, ammonium salts as well as calcium and aluminium sulphates, assist corrosion. W. H. Mawdsley[5] noticed at the acid works of Mt. Morgan, Queensland, that chamber lead did not resist corrosion as well at present as formerly. In view of the great cost of lead in that part of the world, it seems essential that the imported sheets should resist the attack as much as possible. The author suggests suspending in acid chambers sheets of lead containing graded admixtures of foreign metals to test resistances to corrosion, and thus arrive at the quantities of foreign metals permissible in sheet lead to be used in sulphuric acid chambers.

Lead-Arsenic.—A paper by J. Scott[6] aims to explain with illustrations the phenomena that take place in the formation of shot when arsenical lead drops from the perforated ladle at the top of the shot tower.

Type Metal.—Meyer and Schuster[7] examined chemically and microscopically specimens of type of different compositions which were in a good state of preservation and which had become corroded. They found that oxidation was not conditioned by chemical composition, but

[1] Statistics of Julius Matton.
[2] *Atti Real. Accad. Lincei.* **22,** 155 (1913), through *Jour. Inst. Met.*, **10,** 413 (1913).
[3] *Zeit. angew. Chem.*, **26,** 423 (1913); *Jour. Inst. Met.*, **10,** 413 (1913).
[4] *Jour. Soc. Chem. Ind.*, **32,** 771, 811, 847 (1913); *Jour. Inst. Met.*, **10,** 414 (1913).
[5] *Eng. Min. Jour.*, **97,** 954 (1914).
[6] *Metal Industry*, **12,** 245 (1914).
[7] *Das Metall*, **1,** 352 (1914).

was caused by the manner of casting, of cleaning, and of storing. A porous casting favors oxidation, cleaning with petroleum or turpentine oil is preferable to treatment with water or caustic soda, storing in a damp place favors oxidation. Zinsberg, in discussing the paper, states that he found in his experiments that reagents which corroded lead readily attacked type; thus distilled water became turbid after being for a few hours in contact with type, while ordinary water did not. He believes that the lower the lead content of the alloy the greater its resistance to corrosion.

According to G. R. Wagner[1] the alloy Pb 82, Sb 13 and Sn 5 per cent. works equally well for linotype and monotype machines, and for casting page-plates in stereotyping.

Bearings.—In a paper on railway bearings, G. H. Clamer[2] gives the following list of bearing alloys used by some of the leading railroads:

Railroad.	Pb	Sn	Sb
Atlantic Coast Line	85	.....	15
Bessemer and Lake Erie	90	.....	10
Baltimore and Ohio, thin linings	94–96	0.5–1.5	3–5
Baltimore and Ohio, thick linings	86	3–5	10–12
Chicago and Eastern, Minimum	84–85	2	12–14
Chesapeake and Ohio	91.5	1.5	7
Pennsylvania	87	.....	13

It will be noticed that in the Baltimore and Ohio bearings the thick lining, containing more Sn and Sb, is harder than the thin. Besides composition, heat treatment of the alloy has an important influence upon behavior in use. Experience has shown that the results of laboratory tests are borne out by service performances.

"Antimony-Lead-Tin Alloys" is the title of a monograph of 235 pages by E. Heyn and O. Bauer which forms a supplement to the "Verhandlungen des Vereins zur Beförderung des Geverbefleisses" of February, 1914. The authors have traced the constitutional diagram which shows that there exist two ternary alloys, Sn 10, Sb 10, Pb 80 per cent. and Sn 53.5, Sb 4, Pb 42.5 per cent., in which the beginning and end of fusing or solidifying temperatures coincide. A line joining these two alloys in the triaxial diagram gives a series of alloys in which freezing and melting points approximately coincide. Alloys in which these phenomena are far apart show segregation in slow cooling; this difficulty is overcome in part by additions of 2–3 per cent. of copper, as this raises the temperature of the first retardation occurring in cooling while it leaves unchanged the last. The greatest hardness is reached with an alloy of the composition Sn 30, Sb 60 and Pb 10 per cent.; the hardness

[1] *Brass World*, 10, 83 (1914).
[2] *Brass World*, 10, 85 (1914).

of Pb-Sb is increased by Sn, that of Sn-Sb by Pb, that of Pb-Sn by Sb. In general, brittleness increases with hardness; an exception is formed by a series of Sn-rich alloys with less than 25 per cent. Sb, which show an excess of toughness over that expected from hardness; resistance to compression, however, increases with hardness. An addition of Cu increases the hardness as well as the brittleness, and especially so with quick cooling.

Lead Ores

Purchasing Ores and Cost of Smelting.—L. S. Austin[1] under the heading "Smelting Costs and Prices for Silver-Lead Ores" analyzes the prices that can be paid and that are paid by smelteries. An abstract to be of any value would be too long; the paper deserves careful study.

Smelting Practice

Historical.—According to W. M. Flinders Petrie[2] copper was the earliest metal used by the Egyptians; gold came later, in the second prehistoric period, and with it silver and lead; lead was abundant in the 18th dynasty and from then on became very common.

New Publications.—The fourth edition of L. S. Austin's "The Metallurgy of the Common Metals"[3] has been brought out. Some changes in arrangement and text, and several additions, have been made in the chapter on lead and desilverization.

History of Lead Smelting in Wisconsin and Missouri.—The paper by H. B. Pulsifer[4] begins with the statement that lead smelting is a thing of the past in Wisconsin. The author finds that the existence of lead ores was first reported in 1655, and that mining was begun in 1788; the table of production gives as first entry 168 tons of lead for 1821–1823, which were obtained in the ore-hearth. About 1857 the first reverberatory furnace was built, but it could not compete with the ore-hearth, which held its own until 1908 when smelting was given up, and the small amounts of ore mined were sold.

In Missouri lead ores were discovered in 1700; they were treated in the so-called log- or ash-furnace until 1836, when the ore-hearth came into use. In 1842 the first reverberatory furnace was built. Both types of furnace were in operation for many years until 1878, when the St. Joseph Lead Co. erected its first blast furnace. The sublimed lead industry started about 1878 in Joplin. The accompanying table gives in four peri-

[1] *Min. Sci. Press*, **109**, 1711 (1914).
[2] *Eng. Min. Jour.*, **97**, 912 (1914).
[3] Mining and Scientific Press, San Francisco, 1913.
[4] *Min. Eng. World*, **40**, 821 (1914).

ods the number of the different furnaces in operation between 1818 and 1914.

Missouri Lead Furnaces

	Log- and Ash-furnaces.	Hearths.	Air-furnaces.	Flintshire & Tarnowitz Reverbs.	Slag-hearths and Cupolas.	Rectang. Blast Furnaces.	Subliming Furnaces.
1818	Probably more than 50	1	None	None	None	None	None
1855	2	28	1	1	3	None	None
1877	None	26	52	4	7	None	None
1914	None	75	None	4	4	12	8

The Perth Amboy Plant, Maurer, N. J.—A brief description of these works accompanied by photographs is given by H. B. Pulsifer.[1] The roasting is carried on in two hand reverberatories and one Dwight-Lloyd sintering machine. There are four blast furnaces: No. 1 is small and serves for smelting refined antimony skimmings, Nos. 2 and 4 are 42.75 by 160 in. at the tuyère line and have 10 tuyères on a side, No. 3 is 42.75 by 224 in. and has 14 tuyères on a side; the height of the furnaces from tuyères to feed-floor is 18 ft. All furnaces are hand-fed. The slag produced contains SiO_2 32–35, FeO 28–32 and CaO 14–18 per cent.; if its Pb content is 2.5 per cent., it goes to the dump, otherwise it is granulated and resmelted. A large furnace is tapped into a settler; the slag overflows into pots; lead, speiss and matte are tapped at intervals from the settler into pots which are emptied into a coal-fired reverberatory settling furnace, which has one tap-hole for waste slag, two for speiss and matte, and two for lead. The lead from the blast furnace is collected in transfer pots delivering to two stationary casting pots which serve a line of moulds; the bars are remelted and drossed in a liquating furnace before they go to the softening furnaces of the desilverizing department. The treatment of speiss is not taken up in the paper. The matte is poured into basic Pierce-Smith converters, of which there are three, and blown for fume, collected in a flue and a bag house, for slag with Pb 30 and Cu 5 per cent. to be resmelted in the blast furnace, and for blister copper to be refined electrolytically in the copper department.

The refinery has five softening furnaces each of 200 tons capacity, nine desilverizing kettles, five refining furnaces, and three running-out furnaces from which the refined lead is cast into moulds. For the treatment of the zinc crust there are in operation nine Faber-du-Faur distilling furnaces; the rich lead is cupelled in six furnaces, and the resulting doré silver cast into anodes to be parted by the Moebius process. The fumes are recovered in two bag houses; the larger receives the fumes from the

[1] *Min. Eng. World*, 40, 373 (1914).

blast furnaces and converters, the smaller those from the desilverizing plant. The larger bag house is 245.3 ft. long by 59.6 ft. wide, has twelve sections, each with eight rows of 26 bags, 18 in. in diam. and 31 ft. long. The bags are shaken by hand with levers from the outside on the upper staging.

Smelting at Herculaneum, Missouri.[1]—This smelting plant of the St. Joseph Lead Co. is situated on the Mississippi River about 30 miles southeast from St. Louis. It treats the galena concentrate from the Bonne Terre, Leadwood and Doe Run concentrating mills, which are blast roasted in Dwight-Lloyd sintering machines and smelted in blast furnaces. The resulting lead is purified by liquating and poling, the matte is rough-roasted in Holthoff and Wedge furnaces, and added to the blast-roasting charges until it has become sufficiently enriched in copper to be smelted by itself for copper matte which is sold.

The concentrates are received in steel cars, sampled in the cars with 4-ft. post-hole augers 6 in. in diam. by drilling 24 holes to the bottom. The auger is removed with every few inches of depth attained, and part of the drillings are collected in a sample can. In freezing weather the contents of the cars are thawed out[2] in a thaw-house holding eight 50-ton cars and heated by a small coal-fired furnace connected with 350 ft. of 4-ft. pipe. The concentrates are discharged into mixer-bins in such order as to accomplish a rough bedding. The conveyor, passing by the bins, receives their contents through adjustable screw-feeds; it passes in turn under hoppers connected with bins holding the finely divided fluxes, pyrite-cinder, roasted matte and sand, and receives the desired quota of each before discharging into the mixing plant of the Dwight-Lloyd machines where the necessary water is added. The mixing plant contains a revolving drum and Fernholt clay pulverizers.

The Dwight-Lloyd plant contains eight machines 42 by 264 in.; a suction of 5 or 6 in. water is furnished by four No. 110 Sirroco fans. The sinter bed of a machine has the usual depth of 4 in., the speed of the pallets is about 12 in.; one man is employed to clean the grates. The concentrate fed to a machine contains Pb 65–74, S 14, SiO_2 3, FeO 5, Zn 1–5, Cu 0.5, Ca(Mg)O 3–5 per cent.; the sinter contains Pb 45–50, SiO_2 12–15, FeO 17–21, S 4–5, Ca(Mg)O 4–5 per cent.; its lead content may not exceed 50 per cent. as trouble from fusion is likely to occur; the gases contain about 4 per cent. SO_2. The limestone necessary to make up the blast-furnace charge is crushed in a No. 5 Gates crusher. The blast-furnace matte, which enters the blast-roasting charge, is broken in a Blake crusher and in 14 by 36-in. rolls; it is proposed to replace crushing by granulating. The crushed matte is rough-roasted in one Holthoff

[1] Editor, *Eng. Min. Jour.*, **98**, 900 (1914). [2] Editor, *Eng. Min. Jour.*, **98**, 961 (1914).

single-hearth, and one Wedge seven-hearth, furnace. The Holthoff furnace, 36 ft. in diam., is fired with oil-burners instead of from the central gas producer; the hearth makes 1 revolution in 11 min.; in 24 hr. the S content of 40 tons matte is reduced from 24 to 12 per cent. The seven-hearth Wedge furnace, 21 ft. 6 in. in diam., treats 60 tons in 24 hr.; the two lower hearths are oil-fired in order to attain the required large roasting power.

Four blast furnaces, 42 by 192 in. at tuyères, do the smelting. A furnace has 6-ft. steel jackets. The charge column is 17 ft. high; blast with a pressure of 24–34 oz. is supplied by one No. 7 Roots blower, two Connersville blowers of 84 cu. ft. capacity per revolution and one of 68 cu. ft. The tuyères, 4–4.5 in. in diam. and at 16-in. centers, are 15. in. above the slag-tap; a furnace charge, 6000 lb. sinter, 1000 lb. slag-shells, the necessary limestone, and about 12.5 per cent. coke, is made up in a charge-car of the Pueblo type.[1] In tapping into the fore-hearth a rod 20–30 ft. long is used so that the furnace man stands outside of the hood which carries off the fumes. The first matte, with Cu 3 per cent., is handled in hand-pots, but these are to be replaced by ladles to be transported by an electric crane to a barrel-shaped tilting storage furnace for granulating. When the copper content of the matte has reached 7.5 per cent., the matte is treated by itself. The furnace charge contains Pb 40 per cent.; the slag SiO_2 33, FeO 36, CaO 14.5, MgO 4, Al_2O_3 3 per cent.; in addition there are usually present S 2, Zn 4, Pb 1.2 per cent. The CaO content is kept low on account of the inevitable presence of MgO. A furnace puts through in 24 hr. 225 tons of charge and produces 90 tons of lead. The lead well is provided with a pouring-spout which delivers the lead into moulds held in a casting-wheel. The rough pigs go to the refinery, which contains four coal-fired liquating furnaces with cast-iron troughs and water-cooled bridge-walls, two 30-ton refining kettles for poling, and two casting-wheels. The fumes from blast and refinery furnaces are drawn through a flue 900 ft. long and sent to the bag house by a fan 16 ft. in diam. with impeller 8 ft. 1 in. in diam. making 203 r.p.m.; the fan delivers 140,000 cu. ft. gas under a head of 2 in. water. The bag-house building is 216 by 56.6 by 50 ft.; it has four bays 16 ft. high, and 2496 cotton bags, shaken mechanically, which are 30 ft. long, 18 in. in diam., and have 48 threads to the inch. The fume assays Pb 74 per cent. Of the 900 ft. flue, 600 ft. are of steel and balloon shaped, and 300 ft. of masonry with 13-in. walls and 5-ft. jack arches. The dust from the balloon flue is handled by a cyclone dust collector, delivered into a conical bin, and thence passes into a pug-mill to be de-

[1] See Hofman, "Lead," p. 216 (1899).

livered wetted to the main mixer-belt. The chimney of the plant is 360 ft. high and 20 ft. inner diam.

Lead Smelting at El Paso, Texas.[1]—These works were started in 1886, they burnt in 1900, and were at once rebuilt. At present there are available eight Huntington-Heberlein blast-roasting pots and eight lead blast furnaces for the treatment of lead ores. About 3 years ago a new copper division was added to the lead smeltery. Ores are unloaded by hand from the box-cars and gondolas, the work being done by contract; a Brown locomotive crane with a grab-bucket of 40 cu. ft. capacity serves to move ores from the stock pile. Ores are sampled by fractional selection while they are being unloaded; the samples are reduced in four Vezin mechanical samplers, details of which are given in the paper. Sulphides are rough-roasted in three Godfrey furnaces and then blast roasted in Huntington-Heberlein pots. A Godfrey furnace is 26 ft. in diam., two are oil-fired and one coal-fired, the last furnishes the coals for the ignition of the Huntington-Heberlein pots; a furnace burns 0.2 bbl. oil or 0.09 ton of coal per ton of charge, and treats 30 tons in 24 hr., reducing the S content to about 11 per cent. A Huntington-Heberlein pot makes two 6-ton charges in 24 hr.; the blast of 8 oz. pressure is supplied by a No. 7½ Baker blower. The cakes of sinter are dumped on bumping blocks made of old roll-shells and are then broken by hand. The fines formed amount to about 10 per cent.; the S content of the cakes averages 5.66 per cent. Most ores for the blast furnaces are bedded; some ores which are of uniform character and are received in large quantities are collected in bins. Charges are made upon the furnace floor in two larry-cars of 150 cu. ft. capacity, provided with V-shaped drop-bottoms; the components are brought from beds and bins in wheel barrows, weighed, and dumped. The larry-cars, holding 5-ton charges, are raised to the feed-floor by two hydraulic lifts operating at 190 lb. pressure; they are then transferred electrically to the tops of the furnaces and discharged through the bottom. A blast furnace is 46 by 162 in. at the tuyères, which represents an area of 47.25 sq. ft. It has a brick shaft 23 ft. high, and two tiers of steel water-jackets 46 and 24 in. high. The lower jackets have a bosh of 18 in. in a height of 2 ft. 6 in. There are 16 tuyères, 3.5 in. in diam., placed 13 in. from the bottom of the jackets. The daily tonnage ranges from 150 to 200 tons of charge containing 3.2 per cent. S and 14 per cent. Pb; the coke consumption is 14.6 per cent. of the charge; the flue dust formed is only 0.5 per cent. Slag and matte are tapped into small pots which are wheeled to one of two reverberatory oil-fired Rhodes separators; the bottom and sides of these are water-cooled; on the bottom is sprung an inverted arch of silica brick. One of the separators is in regular operation, the other is held

[1] Vail, *Eng. Min. Jour.*, **98**, 465 (1914).

as a reserve; the oil consumption is 15–20 bbl. per day. The slag from the blast furnace assays Ag 0.7 oz. per ton, Pb 1.10 per cent. wet assay (0.50 dry); that from the separator SiO_2 31.2, FeO 30.1, MnO 4.0, CaO 22.9, Al_2O_3 5.4, ZnO 2.8, Cu 0.23, Pb 0.83 per cent. wet (0.51 dry), Ag 0.6 oz. per ton. The waste slag goes to the dump in a train of cars hauled by locomotives burning 15–20 tons of coal. The matte, averaging Pb 12.9, Cu 19.6, Fe 31.5 per cent. and Ag 125.8 oz. per ton, is tapped from the separator and granulated by a double stream of water under a pressure of 60–100 lb. into boxes with sloping sides, from which it is raked out and transported by contract to the Godfrey roasters. The roasted matte is smelted with siliceous material in a blast furnace; from this, slag and matte are run into an Orford fore-hearth[1] with an 8-in. opening in the partition wall. The concentrated matte averages Pb 9.9, Cu 47.9, Fe 20.4 per cent. and Ag 129.6 oz. per ton; the slag, SiO_2 31.3, FeO 29.4, MnO 2.6, CaO 22.5, Al_2O_3 6.7, ZnO 2.4, Pb, wet, 0.75 (0.39 dry) per cent. and Ag 0.42 oz. per ton. The concentrated matte is resmelted in the copper blast furnaces of the plant and the lead wasted. Fumes from the tap-hole are carried off by natural draft through movable hoods connected with 30-in. pipes. The flue dust is briquetted with 10 per cent. lime in a Chisholm, Boyd and White press. The lead bullion is removed through the siphon-tap into small pots, drossed, and ladled into 105-lb. bars; the dross is liquated in a special furnace and returned to the blast furnace. In 1913 a blast furnace was banked for 36 days, and, after starting, soon ran again in a normal way; the best previous record had been 28 days.

Lead Smelting in Utah.—Two articles entitled "Metallurgical Plants near Salt Lake City"[2] and "Early Mining in Utah"[3] show that the Salt Lake Valley was the cradle of the modern practice of lead smelting, that it has held its own in the competition for the treatment of lead ores, and that it has at present three large smelteries: the American Smelting and Refining Co. at Murray, the United States Smelting Co. at Midvale, and the International Smelting and Refining Co. at Tooele.

Smelting at East Helena, Montana.[4]—The characteristics of this plant are that it treats galena concentrate with an average of Pb 40 and S 11 per cent., and adds as flux siliceous gold and silver ore, and limestone, crushed to 5 in. Coarse ores are bedded in bins of 1200–1500 tons capacity in order to obtain a satisfactory charge for blast-roasting; fine ores go direct to the beds from which the rough-roasters are supplied. In winter, the wet concentrate is passed over a heated pan conveyor which delivers to the crushing and sampling mill. The sulphide sampling mill, of the

[1] See Hofman, "*Copper*," p. 150 (1914).
[2] Editor, *Eng. Min. Jour.*, 98, 291 (1914).
[3] Extended excerpt from Ingalls' "Lead and Zinc in the United States," *Eng. Min. Jour.*, 98, 248 (1914).
[4] E. L. Newhouse, *Bull. Am. Inst. Min. Eng.*, August, 1914, p. 1801.

Vezin type, has an hourly capacity of 45 tons; the ore is crushed to 0.41 in., and $\frac{1}{625}$ is taken as sample to be cut down by quartering. The bulk of the silver and gold ore is sampled in a separate mill of the same general design as the sulphide mill; $\frac{1}{25}$ part is taken as a sample. The ore goes direct to the blast furnace in order to avoid loss inherent to the roasting. Single carloads are put through a third mill crushing to $\frac{3}{8}$ in. and taking $\frac{1}{25}$ as sample. Sulphide ore is blast-roasted in 12 Huntington-Heberlein pots and 5 Dwight-Lloyd machines; two new Dwight-Lloyd machines are under construction. The charge of the Huntington-Heberlein pots is made up of direct-converting mixture and rough-roasted matte so as to average S 10 per cent. The matte is roasted in four Godfrey furnaces, each having a capacity of 27 tons per day and reducing the S content from 20 to 10 per cent. A pot has a capacity of 12 tons, treats its charge in 12 hr. with a blast pressure of 8–12 oz. A blown pot is raised with a 20-ton crane, the unagglomerated fines are raked off, and the pot then carried to the breaking floor, and its content dropped. Large pieces are dropped again by the crane; smaller lumps go direct to a Blake crusher set to 3 in. whence the product is hauled to bins of 200 tons capacity. The Huntington-Heberlein division contains four Godfrey furnaces, twelve Huntington-Heberlein pots, and treats 300 tons of charge per day.

CHEMICAL ANALYSES

	SiO_2	Fe	CaO	S	Pb	Zn	Cu
Matte	2.0	42.8	0.4	21.0	14.0	5.4	6.6
Direct-converter mixture	11.4	14.7	2.5	9.4	42.0	3.5	Tr.
H. H. product	9.1	27.9	1.9	5.0	35.0	4.7	2.7

The first Dwight-Lloyd machine, erected 1907, was 30 by 150 in.; the four additional machines and the last two are 42 by 264 in. Until 1912 it was found necessary to use a "grate-dressing" of crushed siliceous rock or limestone to prevent the charge from sticking. This was found to be unnecessary when the manipulation was better understood; the herring-bone grate was later replaced by a straight-slot casting, and a mechanical grate-cleaning device.[1] The whole operation now requires little labor; the charge mixture is trammed from the bins, moistened with 5 per cent. water, brought by a bucket-elevator, a belt conveyor and a Robins automatic tripper to four storage hoppers. The charge is ignited by means of gasoline burners under 80 lb. pressure, the suction ranges from 5 to 8 in. water, the speed is 16–20 in. per min. A machine treats in 24 hr. 90–120 tons of charge and reduces the S content from 12.5 to 3.5–5 per cent. A typical charge

[1] MINERAL INDUSTRY, **22**, 469 (1913).

consists of 75 per cent. milled ore of ¼-in. size, 20 per cent. slime and 5 per cent. flue dust.

CHEMICAL ANALYSES

	SiO_2	Fe	S	Zn	CaO	Pb	Cu
Before roasting	15.0	15.2	11.6	4.1	2.6	39.0	0.1
After roasting	16.8	17.2	4.5	4.0	2.9	41.7	0.4

Experiments with filtering of gases having proved successful as regards life of bags; the roaster gases go with the blast-furnace gases to the main bag house.

There are three active and one reserve blast furnaces. A furnace is 48 by 136 in. at tuyères, has 16 tuyères 3.5 in. in diam., and a working height of 18 ft.; it treats per day 270 tons of charge with 30–40 per cent. Pb, using 12–13 per cent. coke, and a blast-pressure of 33 oz. With the high percentage of lead, small amounts of zinc (5–6 per cent. in the slag) and a good reduction are matters of special consideration. Charges are raised in 9-ton cars to the feed-floor on an incline, the hoisting men raising and dumping the cars; lead bullion is run into 1-ton pots which go to the drossing and moulding plant containing four kettles of 54 tons capacity from which it is tapped into 90-lb. bars; matte and slag are tapped into a fore-hearth from which matte is removed periodically into a Kilker moulding machine[1] to be crushed and transferred to the Godfrey roasting bins, while the slag overflows into a catch-pot and a waste-slag pot; slag-shells are returned to the blast furnaces. The following data represent typical work: Charge, Huntington-Heberlein 36.5, Dwight-Lloyd 52.6; return slag, 15.4, with Pb 31.9 and S 3.8 per cent.; coke, 12.92 (F. C. 10.1) per cent.; matte-fall, 14.1 per cent., with Pb 13.4, Cu 9.7 per cent., Ag 18.7 oz. per ton, sp. gr. 4.2; slag, SiO_2 33.2, FeO 31.9, MnO 2.6, CaO 18.4, MgO 2.1, Zn 5.0, Pb 0.90 per cent. and Ag 0.30 oz. per ton, sp. gr. 3.3; tonnage, 260 tons of charge, with 89 per cent. blast-roasted material, per furnace in 24 hr. There are three brick bag houses 43 by 133 ft. by 50 ft. high, each with 1260 cotton bags 18 in. in diam. and 30 ft. long, connected by flues 1570 ft. long with the roaster and blast furnaces; a suction of 0.70 in. water is obtained by a fan. The gases enter the bag-house with a pressure of 0.40 in. water and a temperature of 36° C. in winter and 92° in summer. The dust is burned in the bays and goes to the roasting furnaces.

ANALYSES, RAW AND BURNED DUST

	SiO_2	Fe	Mn	Bi	Zn	CaO	MgO	S	As	Sb	Cu	Pb
Raw dust	2.6	0.7	Tr.	Tr.	2.4	0	0	10.2	1.2	Tr.	0	68.0
Burned dust	3.2	1.3	Tr.	Tr.	1.8	0	0	7.8	1.6	0.3	0	62.8

[1] MINERAL INDUSTRY, 17, 597 (1908); 18, 493 (1909).

The monthly production is about 6000 tons lead bullion which goes to the refineries of Omaha and South Chicago. G. C. Riddell[1] discussing this paper calls attention to the record of March, 1914, in which month a furnace averaged per day, exclusive of slag-shells, 249 tons of charge with 40 per cent. Pb and 7 per cent. Zn, or 5.5 tons per sq. ft. hearth area; to the light slag-fall, 1 ton of charge making less than 0.5 ton slag; and to experiments under way with a combination of Huntington-Heberlein pots and Dwight-Lloyd machines which bring the S content down to 2–2.5 per cent.

Treatment of Cyanide Precipitate.—The method of forming lead bullion from cyanide precipitate was first used by Taverner.[2] According to Megraw,[3] C. W. Merrill introduced this mode of procedure at the Homestake mills, Lead City, S. D., and has since perfected it in other plants.

The Hall Process.[4]—The aim of this process is to roast sulphide ore or matte in such a way as to oxidize the metal, to expel the S as vapor, and to recover the vapor in the form of flour of sulphur. The roast is carried on at 700–800° C. in a reducing atmosphere of hydrocarbon rich in H with a limited access of air; with a hydrocarbon containing little H, steam is admitted to the furnace. Supposing ethylene to be the hydrocarbon, the reaction taking place may be expressed by $MetS + CH_2 + 2O_2 = MetO + CO_2 + H_2O + S$; with a lack of C there is formed SO_2 as shown by $MetS + CH_2 + 3O_2 = MetO + CO_2 + H_2O + SO_2$; with an excess H_2S is formed $MetS + 2CH_2 + 3O_2 = MetO + 2CO_2 + H_2O + H_2S$. It is therefore essential that the amounts of reagents be correctly proportioned. In laboratory experiments the S content of pyrite was reduced from 48 to 5 per cent. at 800° C. in an atmosphere of producer gas charged with some air and steam. In a mechanically rabbled furnace treating 20–25 lb. ore per day the S content was reduced to 3 per cent., the issuing gas contained less than 0.1 per cent. SO_2, and the weight of ore treated was equal to that of a McDougall furnace. Working tests were carried out by H. F. Wierum at the Balaklala works, Coram, Cal., in an 18-ft. oil-fired McDougall furnace, in a reducing atmosphere containing less than 1 per cent. O and a high percentage of CO. The average of good work showed 24 tons 10-mesh ore treated in 24 hr. with 5.5 per cent. S in the 10-mesh calcine (0.5-in. material, coarse and fine together, averaged 8.8 per cent. S), with an oil consumption of 22 gal. oil (with 25 per cent. asphalt and 23° Bé) per ton of ore, and an SO_2 content of 0.3 per cent. in

[1] *Bull. Am. Inst. Min. Eng.*, Nov., 1914, p. 274.
[2] MINERAL INDUSTRY, **12**, 25 (1903).
[3] *Eng. Min. Jour.*, **97**, 606 (1914).
[4] *Eng. Min. Jour.*, **96**, (1913), Editor, 33; Hall, 35; Liddell, 50; Editor, **97**, 720, (1914); *Min. Sci. Press*, **107**, 2 (1913), Editor; **109**, 518 (1914), Wierum; *Met. Chem. Eng.*, **12**, 140 (1914) (W. A. Hall, U. S. Pat. 1083252, Dec. 30, 1913); *Bull.* 76, *Min. Met. Soc. Am.*, Sept. 30, 1914, p. 134; *Met. Chem. Eng.*, **12**, 718 (1914), Wierum; *Metall und Erz*, **11**, 261 (1914), Schiffner; 413 (U. Wedge, Furnace for carrying on the process, U. S. Pat. 1094953, April 28, 1914).

the issuing gas. The best result for 48 hr. was 5.3 per cent. S in 10-mesh calcine, oil consumption 16–17 gal., SO_2 content of gas 0.06 per cent. It is held by Wierum that 40 tons of 10-mesh ore can be treated with 500 gal. of oil, the S in the ore reduced to 5 per cent., and the SO_2 in the gas kept to below 0.3 per cent.—probably to 0.15 per cent. and less. In all the large-scale work some air was admitted at the bottom; metal and sulphur are oxidized, the SO_2 rises in the furnace and comes in contact with H_2S formed higher up, when $SO_2 + 2H_2S = 2H_2O + 3S$ takes place. If the atmosphere in the middle hearths is too strongly reducing, some organic sulphide is formed which seriously interferes with the production of S. In the furnace the upper two hearths are under a slight pressure, the third has no pressure, and hearths 4, 5, and 6 have a suction of about 4 mm. water. On the upper three hearths burners similar to the Körting under 40–60 lb. pressure are used; on the lower three ordinary atomizing burners. For the collection of the flour of S a Feld gas washer was employed which worked very satisfactorily at first, but soon became clogged with a sticky mass of yellow and gray sulphur. In the laboratory experiments the Cottrell electric precipitation of the sulphur vapor was very satisfactory; a trial of it at the plant was impracticable. At Zalatna, Transylvania, flour of sulphur is washed from gases in charged wooden towers down which trickles a saturated solution of chloride of lime. The cost of unpurified sulphur, with oil at 2.7 cts. per gal., is estimated to be $4.75 per short ton; to this must be added $3.50 for refining.

Oxidation of PbS.—F. Dempwolff[1] studied the oxidation of PbS by an examination of the flue dust from a 14-ton blast roasting pot, and by laboratory experiment. He concludes that at temperatures below 450° C. there is formed mainly $PbSO_4$, and that with slow oxidation in the presence of a catalyzing agent the entire PbS may be converted into $PbSO_4$. On the other hand, the more the temperature rises above 450° C., the greater will be the amount of PbO formed; if it is raised above 750° C. reaction between PbS and $PbSO_4$ and PbO will begin, and the Pb set free will be oxidized by cupellation.

Mechanical Roasting of Lead Matte.—Formerly lead matte was crushed, roasted in the hand reverberatory furnace and added to the blast furnace charge; the result was a diminished smelting power owing to the presence of the matte fines; agglomeration of roasted matte by pounding it in the pot into which it had been drawn was an improvement, but did not go far enough; the present practice is to rough-roast the matte and then blast roast it with siliceous fines. L. D. Anderson[2] discusses the results obtained at the works of the U. S. Smelting Co. at Midvale, Utah, with the Wedge furnaces installed in 1912. In the two

[1] *Metall und Erz*, **11**, 619 (1914).

[2] *Eng. Min. Jour.*, **98**, 51 (1914).

furnaces, 21 ft. 6 in. inside diam., the roof of the top hearth serves as a drier, the following five hearths serve as roasters, and the last two, open at the sides, as coolers. An important innovation is that the upper four roasting hearths have multiple-outlet dampers through which the hot gas of each can escape sideways directly into the flue instead of having to travel upward in the usual way. In starting the furnace on matte, a heavy coal fire was maintained in the large fire-box provided for this purpose. As this eliminated too much S for successful blast roasting, the speed of the rabbles was increased to reduce the time of roasting and increase the tonnage; the rate of firing was diminished until it was finally stopped, but the matte kept on roasting. Experience has shown that a successful roast requires a draft that shall be as low as possible; thus in the main flue the depression is 0.1 in. water, on the first and second roasting-hearths 0.035 in., on the third 0.040, on the fourth and fifth it is scarcely to be measured. A furnace rough-roasts in 24 hr. 75–80 tons lead-copper matte crushed through a 4-mesh screen; reduces the S content from 22 to 5 per cent.; makes less than 8 per cent. flue dust; requires 5 h.p.; uses 8 gal. water per min. entering at 4° C. and leaving at 21°; about 12,000 cu. ft. gas (altitude 4500 ft. and boiling point of water) pass off per min. Galena ore is rough-roasted in the absence of matte. In making the change, two or three floors are left uncharged; this may require use of the fire-box to maintain the heat, but frequently the heat stored in the brickwork and that given off by the ascending gases has been sufficient to kindle the new charge.

The Wedge furnace is in operation now at several lead plants for this work.

Blast Roasting.—J. Savelsberg[1] patented the introduction of steam with air in the blast roasting operations carried on in pots. The steam blown in with the air is to condense in part in the upper cooler layers of the charge, moisten them and thus prevent dusting; in part it is to be decomposed by the glowing fuel, form water gas and thus promote the sintering operation.

A. F. Plock[2] patented a down-draft sintering machine which resembles in principle the well-known Dwight-Lloyd apparatus.

Another form of sintering apparatus is that of J. E. Greenawalt[3] which consists of a tilting sintering pan supported by hollow trunnions, connected with a suction fan, and provided with a grate to carry the ore-charge. The charge is to be ignited from two oil-burners of special construction which permit uniform ignition of the whole upper surface. A later patent[4] refers to an improvement of the grate which is made of interlocking sections instead of a single piece.

[1] U. S. Patent No. 1103318, July 14, 1914.
[2] U. S. Patent 1089153, March 3, 1914.
[3] U. S. Patent 1088818, March 3, 1914.
[4] U. S. Patent No. 1098035, May 26, 1914.

The patent of F. D. Weeks[1] has been reissued[2] and assigned to the Dwight-Lloyd Sintering Co. An improvement on the Dwight-Lloyd sintering machine has been patented by E. H. Laws[3] which consists in an adjustable upper row of pallets, so that these when passing over the dead-plates at the ends of the suction box or the edges of the box itself shall not wear off the plates or the edges.

W. W. Norton[4] compares the work of Huntington-Heberlein and Dwight-Lloyd roasting apparatus at the Murray plant, Salt Lake City, of the American Smelting and Refining Co., where there are in operation 23 Huntington-Heberlein pots treating in 24 hr. 400 tons of charge and two Dwight-Lloyd machines treating 220 tons. He finds that with both apparatus the S content of a charge must lie between 15–18 per cent., and that, as regards the cost of installation, the Huntington-Heberlein plant is more expensive than the Dwight-Lloyd. In comparing the cost of roasting, the unit of sulphur elimination is taken as a basis, as the roasted product of either apparatus retains about the same amount of S; thus the Huntington-Heberlein plant, which can treat ore with a slightly higher S content than the Dwight-Lloyd, will reduce the S content of 17–18 per cent. in the charge to 5 per cent. in the product, while with the Dwight-Lloyd the corresponding figures are 15–16 per cent. and 4 per cent. S. In 1913 the cost of roasting in Huntington-Heberlein pots was 5 cts. less per ton of charge, and during the first 3 months of 1914, 3 cts. less than in the Dwight-Lloyd machines. Considering the range of chemical composition of charge, there appears to be little difference. As to the physical character of charge, the Huntington-Heberlein pots have to work within narrow limits, while the Dwight-Lloyd machines can treat very fine materials (*e.g.*, slimes) which the Huntington-Heberlein pots cannot. With reference to lead losses, the impression prevails that the Huntington-Heberlein pot is in no way inferior to the Dwight-Lloyd machine. The sinter from the Huntington-Heberlein is dense and firm, that of the Dwight-Lloyd porous or cellular. In smelting charges with 11.5 per cent. coke in two short test runs using in one case Huntington-Heberlein material, the slag ran Pb 0.63 per cent., and the matte 10.7 per cent., while with the Dwight-Lloyd material, the values were Pb 0.91 per cent. and matte 14.90 per cent. The tonnage of both apparatus appears to be about the same.

Discussion of the paper brought out other interesting facts. Thus A. S. Dwight[5] states that at several plants it has been found that with Dwight-Lloyd sinter the fuel requirement is less than with the Hunting-

[1] MINERAL INDUSTRY, 18, 492 (1909).
[2] U. S. Patent No. 13758, June 23, 1914.
[3] U. S. Patent No. 1097592, May 19, 1914.
[4] *Bull. Am. Inst. Min. Eng.*, August, 1914, p. 1993; *Eng. Min. Jour.*, 98, 297 (1914).
[5] *Bull. Am. Inst. Min. Eng.*, Nov., 1914, p. 2741; *Eng. Min. Jour.*, 98, 404 (1914).

ton-Heberlein material, *e.g.*, 10 *vs.* 11.5 per cent.; it is a common experience that with an excess of fuel there occurs overfire as well as a high lead content of slag and matte. The reason given for the lower percentage of fuel required is that in the product of a Huntington-Heberlein pot the iron is present mainly as Fe_2O_3, while in that of the Dwight-Lloyd machine it is found combined as FeO. As to furnace speed, the following data referring to a blast furnace 48 by 162 in. at tuyères are of much interest.

	Average Tons Smelted per Furnace Day.
1. With Brückner roaster product	180
2. With Huntington-Heberlein product	200
3. With H.-H. product and ore fines largely removed by screening	227
4. With Dwight-Lloyd product and ore fines largely removed by screening	285

Case 4 shows a gain of 25 per cent. over Case 3.

Regarding the S content of the charge, Dwight maintains the opposite of Norton, one plant, *e.g.*, having 11–12 per cent. S for the Dwight-Lloyd charge, and 10–11 per cent. for the Huntington-Heberlein. He also makes the point that in Norton's comparison of costs such items as interest and investment, depreciation, etc., have been omitted, which would throw the balance in favor of the Dwight-Lloyd, and that the Dwight-Lloyd handles the fines which the Huntington-Heberlein cannot treat. Dealing, lastly, with the loss of lead in the blast roast proper, Dwight states that in a smeltery at which Huntington-Heberlein apparatus was replaced by Dwight-Lloyd the loss with the former was 3 per cent., and is now 0.75 per cent.

G. C. Riddell[1] gives his experience with the two apparatus at the East Helena plant, Montana, of the A. S. & R. Co. which is more favorable to the Dwight-Lloyd, in that with the prevailing high lead-content charge (35 to 40 per cent. Pb) the tonnage has been greater, the fuel consumption lower, and the amount of lead in slag and matte smaller. The record of two test runs, each lasting a week, gave the following results:

RESULTS OF TWO 1 WEEK TEST RUNS

Blast-roasted Material.	Coke, Per Cent., Wt.	Per Cent. F.C.	Charge.		Zn, Per Cent.	Slag.		Sinter.	S, Per Cent. Ore Charge.	Matte-fall, Per Cent., Wt.	Matte	
			Tons.	Pb, Per Cent.		Pb, Per Cent.	Ag, oz. per ton.				Pb, Per Cent.	Cu, Per Cent.
H.-H.	13.39	10.6	209	30.3	5.0	1.84	0.28	66.7	4.2	17.9	22.9	10.2
D.-L.	11.52	9.0	218	30.5	5.1	0.94	0.22	88.4	3.7	15.6	12.1	8.5

[1] *Bull. Am. Inst. Min. Eng.*, Nov., 1914, p. 2744; *Eng. Min. Jour.*, **98**, 495 (1914).

In the blast roast, the Dwight-Lloyd charge with 43 per cent. Pb in the sinter gave a better S elimination (10.9 *vs* 4.6 per cent. S) than the Huntington-Heberlein with 38 per cent. Pb (10.0 *vs* 5.1 per cent. S), which received a coarser concentrate than the Dwight-Lloyd. The lead loss and the cost of treatment with the two apparatus was the same. Placing the experiences of Norton (Murray) and Riddell (East Helena) in parallel gives:

Item.	At Murray.	At East Helena.
	Advantage Lies in Favor of	
Cost of installation	D.-L.	D.-L.
Cost of roasting	H.-H.	Even
Adaptability to charge	D.-L.	D.-L.
Metal loss	Even	Even
Physical condition of product	H.-H.	D.-L.

Gore,[1] discussing some successful experimental work in the filtration of blast roasting gases and fumes at East Helena, states that the Dwight-Lloyd machines were found to be more sensitive to slight variations in the charge than the Huntington-Heberlein pots, and gives as one reason for this that the Dwight-Lloyd machines received the finer material.

F. Dempwolff,[2] in his study of the oxidation of PbS referred to above, found that in blast-roasting in a Huntington-Heberlein pot the loss of lead by volatilization amounted to 0.8 per cent. of the lead content of the charge. An examination of the flue dust formed showed that at the beginning of a blow with a gas temperature reaching 150–160° C. the dust was black; it grew lighter from intermixed $PbSO_4$ and remained gray colored up to 250° C.; above this temperature it was white, showing that little undecomposed PbS escaped with the gases.

Smelting in the Ore-hearth.—H. B. Pulsifer[3] reviews the smelting of lead ores in the ore-hearth. He discusses the history, chemistry and practice; many details of American practice are given, illustrated by photographs of apparatus and plants in Missouri and Illinois. The ground covered is familiar to readers of these abstracts. The following two tables give concise information regarding practical details.

Smelting Lead Ores in the Blast Furnace.—Under this heading I. A. Palmer[4] discusses some leading features of the present practice. There is little difference in the general form of furnace. The cross-sectional area at the tuyère-level is 42–46 in. by 160–160 in.; some furnaces are 48 in. wide; a smaller width is held to furnish better slags. The working

[1] *Min. Sci. Press*, 108, 416 (1914).
[2] *Metall u. Erz.*, 11, 619 (1914).
[3] *Min. Eng. World*, 40, 451–455, 501–505 (1914).
[4] *Bull. Am. Inst. Min. Eng.*, July, 1914, p. 1447.

ORE-HEARTH PLANTS

Plant.	Hearths.	Length.	Tuyères.	Cooled.	Hoods.	Operated by	Charge.
Federal	30	4 ft.	8	Water	Double	2 men 3 shifts	7500 lb. coke
Collinsville	24	4 ft.	8	Water	Single	2 men	7000 lb. coke
Joplin	6	4 ft.	.....	Air	Single	2 men 3 shifts	7000 lb. coal Limestone
Webb City	6	5 ft.	10	Air	Single	Idle	7000 lb. coal Limestone
Granby	5	4 ft.	7	Water	Double	4 men 1 shift	14,000 lb. coal Sl. lime
Galena	4	5 ft.	10	Air	Single	2 men 4 shifts	7000 lb. coal Limestone

BAG HOUSES

	Federal.	Collinsville.	Webb City.	Granby.	Galena.
Size, ft.	60 × 150	38 × 78	56 × 75	42 × 90	68 × 100
Material	Brick	Brick	Wood above brick	Sheet iron above brick	Wood above brick
Compartments	1	4	1	1	1
Bags	1614	2160	720	640	680
Cellars	6	20	5	8	.....
Bag size	18 in. × 26 ft.	18 in. × 36 ft.	18 in. × 25 ft.	18 in. × 30 ft.	18 in. × 30 ft.
Bag material	Cotton	Cotton	Cotton	Cotton	Cotton
Fans, in	134 × 68 Buffalo	196	100 Buffalo	96 × 36 Am. Blow.	90 Buffalo
Flue, ft.	1794	600	1150	950	800
Serves	Hearths	Hearths and blast furnace	Hearths and cupola	Hearths	Hearths
Built	1901	1903	1910	1904	1902

height is 15–18 ft. The water-jackets are usually of soft steel; the bottom of a jacket has recently been made inclined outward so that scale and mud are collected away from the fire-sheet and easily washed out. The angle of bosh of side-jacket is under 20°, usually 10–11°, and the flare of the brick shaft above is 1 in. to 1 ft. or less; end-jackets and walls are vertical. With a charge made up largely of blast roasted ore, the flare of a side is less than with raw ore, which has to descend in the shaft more slowly to be prepared for the smelting zone. The tuyères are usually 16 in. apart and have a diameter of 2.5–4 in.; with a coarse charge, a wide furnace, and a low blast pressure, a small diameter is favored. Charges are now always fed mechanically; the throat of a shaft is provided with spreaders which deliver the charge toward the sides where most of the fines remain, while the coarse parts roll toward the center. Preparation of ore-charge through blast roasting has greatly changed its physical and chemical character. With the exception of flue dust, all materials with 12–18 per cent. S and the desired proportions of SiO_2 and bases are satisfactorily blast roasted; flue dust is therefore preferably briquetted; a proper mixture of blast- and roasting-furnace dust frequently becomes self-binding when moistened. Blast-roasted ore is coarse and porous, and has a uniform composition; fine material which usually differs in composition from the coarse is therefore practically absent. The harm-

ful effect of fines is mechanical and chemical: mechanically they decrease furnace speed, increase the amount of flue dust, and cause the formation of accretions and blow-holes; chemically they cause irregularities in the formation of slag and matte owing to their separation from the coarse by quicker descent through the furnace. This is due to natural fall through openings in the charge and to the jigging effect of the blast. In pre-roasting in a mechanical furnace, sulphides containing some blende remain largely unaltered; the same is the case in blast roasting; the result is that the refractory ZnS is largely collected in the fines.

Reduction in the blast furnace is caused by metallic iron, by solid carbon, and to a small extent by carbon monoxide and by the reactions of lead sulphide upon oxide and sulphate; the solid reagents must be in close contact if the chemical processes are to proceed satisfactorily. The harmful effect of the separation of fines and coarse of different compositions is well shown in the smelting of roasted matte with siliceous ore in the blast furnace. This has always caused trouble until the rough-roasted matte was first blast roasted with siliceous fines.

The chemical composition of the slag to be made, its fluidity, and the temperature of the furnace form some of the leading considerations governing blast-furnace work. Modern research has exploded the idea of slags being definite chemical compounds; the typical slags, however, retain their former importance; they are considered as representing certain mixtures of SiO_2, FeO, and CaO which have been found to do satisfactory work, but strict adherence to certain ratios of FeO and CaO has become obsolete; cheapness of available fluxes on the other hand forms an important consideration. Slags, made at present, contain SiO_2 35–37, CaO(MgO, BaO) 24–26 per cent., if the amounts of Al_2O_3 and ZnO in the ore are low.

Metal losses are much smaller than they used to be, owing to better practice and to the recovery of dust and fines in bag houses. At present the criterion of good work is not simply a low percentage of Pb in matte and slag, as this has been found to be frequently accompanied by increased losses in dust and fume. Carrying reduction too far may be more harmful than not carrying it far enough.

Bag houses are expensive to build and to operate; they may even show practically no profit[1] and may introduce difficulties by collecting volatilized As, Sb, Cd, Se, Te; hence the aim is to produce as little dust and fume as possible.

The coke consumption has received some study. Formerly the percentage of coke consumed was the criterion in comparing the work of furnaces; to this figure has been added the percentage of fixed carbon of

[1] Eilers, MINERAL INDUSTRY, 21, 555 (1912).

the coke; no generally accepted standard as to the physical characteristics of the coke exists as yet. Thus with a "good" coke, 10 per cent. of the weight of the charge as fixed carbon, excluding weight of slag and coke, is considered to be a low figure. Moistening charges has the effect of rendering fines porous; thus with fine ore a wet charge requires less coke than a dry. With the modern furnace running quickly on coarse charges, there is little need of wetting the charge. The blast pressure ranges from 30 to 40 oz. per sq. in.; this is lower than when fines are fed to a considerable extent. The separation of matte and slag in a special reverberatory furnace is in operation only at a few plants; the furnace gives trouble when zinc is present, causes volatilization loss, and is costly. Prolonged settling is not necessary with a hot slag of correct composition, the usual fore-hearth doing the work satisfactorily.

Discussion of the paper by L. S. Austin[1] refers to the following points: Blast-roasting costs 50–75 c. per ton, hand reverberatory work $2.00; use of blast-roasted material has doubled the smelting power, but the best results are obtained by charging some crude ore with it; the saving to be obtained by mechanical handling is generally exaggerated; expansion of the furnace from the top of the jackets to the throat for the retardation of the gas current has lost its former importance with a charge made up largely of coarse material; gases at present travel through a coarse charge with a velocity of 22 ft. per sec. as against 5 ft. with a fine charge; owing to the low CO content (about 5 per cent. by volume), they can have little reducing effect; any attention paid to the shape, size and direction of tuyères is wasted effort, as the blast, as long as there is enough of it, passes through the charge of the path of least resistance; the practice of returning slag-shells to the charge is being abandoned, as the advantages accruing from aid in smelting and from recovery of entangled matte are more than balanced by the disadvantages of displacement of charge; the doubtful prediction is made that in the near future lead ores will be smelted in the reverberatory furnace, and the fume formed recovered by filtering, the reduction in fuel from 90 cts. per ton of material smelted to 60 cts. being the leading advantage.

L. D. Anderson[2] brings out in his comments that at Midvale furnaces with a bosh angle of 10–11° gave a hotter slag, a larger yield in lead bullion, and burnt off more S, about 50 per cent., with a consequent lower matte-fall, than one with an angle of 20°; that a furnace incrusted near the throat often does better work than when put in blast, suggesting contraction of the throat area; and that daily assays of flue dust and bag-house fume indicate the degree of reduction going on in the furnace.

[1] *Bull. Am. Inst. Min. Eng.*, Nov., 1914, p. 2722.
[2] *Loc. cit.*

Feed-floor of Blast Furnace.—In blast-furnace plants, especially in those of earlier date, it is not uncommon to find dust and fine particles of ore dropping through the crevices of the planks which form the feed-floor. In order to correct this nuisance, the Tennessee Copper Co.[1] constructed a dust-proof feed-floor of arches of corrugated galvanized steel covered with concrete which has met all requirements.

Lead-well.—Some interesting remarks concerning the levels of the slag- and the lead-discharges in a blast furnace with Arents siphon-tap have been made by Von Schlippenbach.[2] It is known that the level of the lead in the furnace is always lower than outside. If the slag- and lead-discharges are placed on the same level, some speiss and matte will remain in the crucible and will not run out with the slag when this is tapped. The discharge of the lead is therefore always placed higher than that of the slag in order that the level of the lead in the furnace may reach up to the tap-hole for the slag. In fact, most furnacemen by closing up the lead-discharge periodically will force the lead to rise in the furnace, until it runs out with the slag, and thus insure a complete outflow of speiss and matte; usually little speiss is made, and a slight bath of matte covering the lead is desirable for the solution of impurities which do not belong either to the slag or the bullion. The author gives a calculation for the conditions of his plant at Stolberg, Rhenish Province, Prussia, which shows how high his lead-level outside must be above his slag-tap.

Blast-furnace Drawing.—A side elevation, part front elevation and part vertical cross-section of a modern lead blast furnace of the Cia. Minera de Peñoles at Mapimi, Durango, Mexico, built by the Denver Engineering Works, Denver, Colo., is published in the *Engineering and Mining Journal*, **97**, 568 (1914). The furnace is 46 by 142 in. at the tuyères and 108 by 182 in. at the throat; the working height is 21.6 ft.; there are two steel jackets, 6 ft. high, and eight 5.4-in. tuyères on a side provided with gate-valves.

Calculation of Charge.—A paper by R. Chauvenet[3] entitled "Indeterminate Cases in Mixing Ores for Calculation of Furnace Charges" deals with this important subject.

Heats of Formation of Slag.—The heats of formation of some silicates of iron and manganese have been determined by Wolgodine[4] with the Le Chatelier method. The results are given in the accompanying table.

The data differ from those found in Hofman's "General Metallurgy" (1913), p. 101.

[1] Barbour, *Eng. Min. Jour.*, **98**, 1098 (1914).
[2] *Metall u. Erz*, **11**, 652 (1914).
[3] *Met. Chem. Eng.*, **12**, 626 (1914).
[4] *Rev. Russ. Metall. Soc.*, **1**, 427 (1913), through *Rev. Mét. Extr.*, **11**, 395 (1914).

Composition.	Heat of Formation.	
	For 1 Gram.	For 1 Mol.
$SiO_2.FeO$	44.5	5,905
$SiO_2.2FeO$	98.5	20,133
$SiO_2.MnO$	58.8	7,725
$SiO_2.MnO.FeO$	67.0	13,597

Chemical Formulæ for Blast-furnace Slags.—It is generally held that the slags produced in blast furnace operations are mixtures of various silicates. Liddell[1] has furnished a series of seven diagrams which permit a quick determination of the rational from the ultimate chemical analysis of a slag. With a slag, *e.g.*, of the composition SiO_2 34, FeO 32, CaO 24.90 per cent., consultation of the proper diagram shows it to be composed of $3(FeO)_2.SiO_2 + 2(CaO)_4.(SiO_2)_3$.

Speiss Pot.—A blast furnace making speiss has to be run hot in order to keep the speiss fluid. When the speiss is run into pots, the latter do not last for any length of time, but crack. At Deloro, Ont., speiss pots are in use in which at three equidistant places channels are cast, reaching half-way down the sides, which reduce the thickness of the wall to $\frac{1}{8}$ in. On either side of a channel is a lug through which passes a double-headed bolt with a nut on each end. The basal idea of the improvement is that if the casting cracks, it will do this at the thin channel wall, when the crack can be luted and closed by tightening the bolts.

Granulating Matte.—Blast-furnace matte is usually crushed in rock breakers and rolls before it is roasted. Objections have been made to the use of granulated matte because it was held that rounded granules did not roast as well as angular crushed material; experience at El Paso and other places has shown that there is no difference between the behavior of the two kinds of material as long as the granules are sufficiently fine. Hallett[2] describes with sketch the granulation of copper matte at Humboldt, Ariz. Here a 4-in. pipe delivers to two 3-in. pipes water under a constant pressure of 60 lb. which impinges upon a thin stream of matte, issuing from a cast-iron pot, and granulates it; the stream of water and granules flows down an inclined trough lined with cast-iron plates, and is collected in wooden bins having vertical sides and an inclined bottom; the water overflows continuously, and the granules are discharged at intervals through a sliding gate.

Converting Lead Matte.[3]—An interesting modification of the usual method of converting lead matte in a basic barrel-shaped converter has

[1] *Eng. Min. Jour.*, **97**, 318 (1914).
[2] *Colo. School Min. Mag.*, January, 1914; *Eng. Min. Jour.*, **97**, 374 (1914); *Min. Sci.*, **69**, 57 (1914); *Min. Sci. Press*, **108**, 296 (1914).
[3] Kuchs, *Bull. Am. Inst. Min. Eng.*, July, 1914, p. 1752.

been developed and put into operation at the Tooele plant of the International Smelting Co., Tooele, Utah. It consists in blowing to copper the matte from the lead blast furnace without the addition of siliceous ore, and collecting the volatilized lead in woolen bags. The heavy oxide slag and the metallic copper are transferred to converters treating copper matte. Here the copper oxide previously formed is sulphurized, the metallic copper taken up by the matte, and the iron oxide utilized in fluxing siliceous ore. The advantage of the innovation lies in the avoidance of the large amount of slag formed in the ordinary process by the scorification of about 45 per cent. of the lead of the matte, which has to be resmelted in the blast furnace, and in the prolonged life of the filtering bags.[1] The plant has five stands of horizontal cylindrical converter shells, 96 by 150 in., lined with magnesite brick. Three converters serve to treat lead matte; the gases are drawn by a No. 20 Sirocco fan of 180,000 cu. ft. capacity through a hopper-bottomed steel flue provided with inlet for cold air to reduce the temperature, and delivered into a brick flue with branches leading into the bag house provided with 960 woolen bags, 18 in. in diam. and 30 ft. long and 24 threads to the inch. The remaining two converters treat copper matte, the gases passing through a steel flue to a stack 16 ft. in diam. and 150 ft. in height. The gases from the lead matte contain sufficient lead and zinc to neutralize all SO_3 formed; in fact 50 per cent. of the zinc in the matte passes off as ZnO against 10 per cent. when siliceous ore is added to the converter charge. The gases enter the bag house with a temperature of 99–110° C. It takes about 2 hr. to blow a charge of 10 tons lead matte. Incrustation of the vessel by magnetite occurs to some extent on the wall opposite the tuyères and is heaviest at the mouth owing to the spattering of the charge, but with a throat of sufficient diameter this evil is not serious. Corrosion at the tuyères is more severe than in blowing copper matte, and requires more frequent patching. More or less continuous punching of tuyères is a necessity. At the beginning of a blow, heavy dense fumes are evolved, they diminish in volume when the blow is about half over, and gradually disappear; at the same time the flame becomes more and more visible; when plainly visible, the weight of the matte, retaining 1.0–1.5 per cent. Pb, has been reduced to 60–70 per cent. of the original charge.

Condensation of Smelter Smoke.—C. Schiffner[2] reviews in a long paper the improvements which had been undertaken in overcoming smoke troubles since the publication of C. Hering's work in 1888. The leading betterments in the collection of flue dust have been made in the United States; they are represented by the bag house, the wire system, and the

[1] See solution of this question by H. H. Alexander, given below.
[2] *Metall u. Erz*, 11, 257, 278 (1914).

Cottrell process. A possible improvement upon Cottrell by Püning (employment of atomized spray of water as discharge electrode) is noted. Sulphurous gases have been rendered harmless by dilution through the Wislicenus tower and the system of Schwabach, the latter diluting furnace gases by means of air introduced through a fan, a method hardly suited for a considerable volume of gases. Experiments made by a Saxon commission[1] consisted in moistening SO_2-bearing gases by passing them through a hydraulic centrifugal fan and then conducting the mist through an underground flue filled with sticks, twigs, stones, etc., and covered with loose earth acting as a filter. The Thiogen process has already been discussed in these reviews.[2] The Hall process is treated under the head of Roasting, page 477.

The author records laboratory experiments carried out with the Cottrell process for the condensation of Sb_2O_3 which were eminently successful. Investigations with the Prüning system for the collection of SO_2 from gases gave unsatisfactory results, the absorption being too small. Substitution of dilute soda solutions for water was not effective on account of short-circuiting; negative results were obtained from experiments with the absorption of SO_2 gas in watered coke-towers.

The Bag House.—H. H. Alexander[3] reviews the history of bag filtration, gives details of the filtering plant of the Globe S. & R. Co. at Denver, Colo., and discusses filtering materials and some shaking devices for bags.

The filtering plant at the Globe smeltery was installed in 1890 with 1458 bags; in 1900 the number was increased to 2800, the present number. The general construction is shown in four drawings. The building is 149 ft. 8 in. by 67 ft. 4 in., and 40 ft. 2 in. high from basement floor to eaves, is of red brick, has a roof of corrugated iron laid on 1-in. boards supported by a timber framework; the roof carries a louver. The basement, 10 ft. high, is divided by 13-in. walls, spaced 8 ft. apart, into 18 bays; the walls carry the thimble-floor made of No. 10 sheet-iron plates riveted together. The thimbles, 17 in. in diam. and 10 in. high of No. 14 sheet iron, are spaced 2 ft. 1 in. apart, three rows to a division. The woolen bags, 31 ft. long, are fastened at the lower ends with soft iron or copper and are suspended by similar wire which is wound a few times around a 2 × 12-in. plank extending over a row of bags and supported by cross timber. The bags must be hung in such a manner that they will stand straight when inflated. A bag deteriorates first at the lower end; this is cut off and the suspension wire lengthened. The gas from the furnace is aspirated through a long cooling flue by means of a fan, which delivers to a main

[1] MINERAL INDUSTRY, **22**, 474 (1913).
[2] MINERAL INDUSTRY, **20**, 491 (1911); **21**, 559 (1912); **22**, 474 (1913).
[3] *Bull. Am. Inst. Min. Eng.*, August, 1914, p. 2001.

from which 24-in. branches provided with dampers lead into the bays. The dust, dislodged from the bags by shaking, is collected in the basement, fired, moistened, and removed to the blast furnaces.

As regards filtering material, a thin layer of absorbent cotton is ideal, but impracticable. Cotton bags are more readily corroded than woolen, which cost from three to four times as much; in the end wool is the cheaper material. Woolen cloth treated with $TiCl_3$ resists the corrosion effect of H_2SO_4, but loses its filtering power owing to the adhesion of the dust and the folding up of the nap around the strands. In order to diminish corrosion, it is essential to prevent as much as possible the formation of SO_3. In converting lead matte in a basic vessel the bags were destroyed in 30 min. on the finishing blow to blister copper when the lead content of the charge had been reduced to below 2 per cent., and not enough PbO was set free to combine with the SO_3 formed. The temperature in the flue back of the converter ranged at the entrance from 425 to 700° C., and at the exit from 200 to 370° C.; it is therefore included in the conversion range for SO_2 into SO_3. The correction was made by increasing the gas-inlet of the flue, and speeding up the suction fan; this drew in more air and diluted and cooled the converter gas. The result was a lower SO_2 content of the gas, 4 *vs.* 9 per cent. vol., a temperature of 315° C. at a distance of 25 ft. from the converter, and an increase in life of cotton bags to over 1 year. In cupelling, the S from the coal may be sufficient in amount to attack filtering bags, in spite of the prevalence of PbO in the gases, unless similar precautions are taken. Selenium has been found to be harmful, as the SeO_2 is reduced to Se by SO_2 which is converted into SO_3.

Exhaustive tests made on the critical temperatures of cotton and woolen bags showed that the tensile strength of cotton begins to decrease upon exposure for 48 hr. to 100° C., while with a woolen bag the same takes place only after 96 hr. to 135° C. A 1-hr. treatment begins to affect cotton at 126° C. and wool at 188° C. Unwashed wool resists corrosion better than washed, but owing to the difficulty of weaving, bag-cloth is made from washed wool and then treated with grease. In cotton, the number of strands per in. varies from 30 by 30 to 48 by 48; in wool it is usually in the twenties. The following is a specification for woolen cloth: The weight is to average 12 oz. per yd. and the tensile strength is to be not less than 21.5 lb. per lineal in. The test pieces are to be square, 3½ in. on a side, and the pull is to be against the warp. The fabric is to contain not less than 85 per cent. wool fiber, estimated by taking the difference between 100 per cent. and the sum of grease, dirt, moisture, burrs, and cotton fiber, and to be practically free from vegetable matter of all kinds. The weave is to be 22 ends by 20 picks per in.

Woolen yarn is used for sewing woolen cloth, linen thread (No. 40 Barbour's Irish linen) for cotton; the cloth is folded to form a double lap seam and sewed with a machine having a lock stitch. The number of bags in a compartment varies from 80 to 1000. As usually one or two compartments are cut out for shaking, cleaning, etc., it is not advisable to have a very large number—the Globe smeltery has 81. The filtering area depends upon the volume of gas, the amount of solids per cu. ft., the adhesion of fume to cloth, and the shaking of the bags. Thus one bag house filters per bag per min. 130 cu. ft. gas, recovers 5 lb. fume in 24 hr., and is shaken once in 24 hr.; another filters 70 cu. ft. gas, recovers 27 lb. fume, and is shaken every 3 hr.

Shaking of bags by hand gives the best results, but is replaced by mechanical shakers owing to the expense and the disagreeableness and unsanitary character of the work. Mechanical shaking is accomplished by striking the inflated bag lengthwise, jerking up and down quickly the deflated bag, by swinging back and forth, and combining the last two movements; the last arrangement is described with drawings.

It is generally accepted that a good ventilation lengthens the life of a bag; a stack 21 ft. 6 in. in diam. and 68 ft. above the roof taking care of 15,000 cu. ft. gas per min. with a draft of 0.05 in. water has proved satisfactory with the gas entering at 45–55° C.; some plants use an exhaust fan. The Wislecenus smoke stack[1] worked satisfactorily with converter gases, but the rain beating through the lattice-work caused rapid deterioration and forced abandonment of the device.

L. D. Anderson[2] treats of bag-house filtration with special reference to the advances made at the Midvale plant of United States Smelting Co. Here woolen bags woven of raw wool give sufficiently long life to warrant the greater expense over cotton. From 0.5–0.7 cu. ft. gas usually pass per min. with a pressure of 1–2 in. water through 1 sq. ft. of filtering area; larger amounts of gas, *e.g.*, 15 cu. ft., have been filtered, but require a higher pressure and this decreases the life of a bag. At Midvale the dust from a bay is caught in a V-shaped air-cooled steel hopper from which it is removed by means of a screw conveyor into a car. The rectangular or circular chamber common for receiving a conveyor has been found to become choked with flue dust; it is therefore omitted. Bags are freed from dust by replacing the pressure in the bags by a vacuum, and repeating this change two or three times. While not as efficient as hand or mechanical shaking, it is simpler and healthier, and satisfactory if repeated every 8 hr.; at the same time it prolongs the life of the bags. Neutralization of free SO_3 in roaster gas is accomplished by the Sprague

[1] Mineral Industry, **20**, 490 (1911).
[2] *Bull. Am. Inst. Min. Eng.*, July, 1914, p. 1689.

process;[1] blast-furnace gas contains too little SO_2 to need preparatory treatment. The filtration of roaster gas is more important than of blast-furnace gas, as it contains more values. At Midvale, dust assays of the former show Pb 35–42 per cent. and Ag 10 oz. per ton, while the figures for the latter are Pb 18–22 per cent. and Ag 1 oz. per ton. Cooling of gas is an essential prerequisite for filtering in order to cause coalescence of the finely divided dust; uncooled gas will show visible clouds when it comes in contact with the cool air after passing the filters; overcooled gas will cause condensation of moisture accompanied by corrosion of the filter fabric by H_2SO_4, unless this is neutralized. Thus, at Midvale, feeding of slaked lime into the cooling steel flue near the extrance and exit of the gases corrected the corrosion which occurred when lime was introduced only at the exit. Three methods of cooling are commonly used: Admission of air is effective, but can have only limited application owing to the increased volume of gas to be handled. Passing gas through metal flues is a common practice; experiment has shown that, within certain limits, cooling is proportional to the square root of the velocity of the gas; in other words, the gas must travel quickly. Wet condensation is being now used more than formerly, but care must be had not to approach too closely the saturation point, as dampness of gas is fatal to the life of a bag.

At Midvale, the gas of the roasters is kept separate from that of the blast furnaces; the dust from the former carries 9–16 per cent. As, is briquetted with other flue dust and fine ore, the lime fed for neutralization acting as a binder, and added to the blast-furnace charge. The dust from smelting contains 35–45 per cent. As, and is treated for As_2O_3 (99.5 per cent. pure). If the dust carries over 45 per cent. As, there is danger of self-ignition. This phenomenon was noticed in connection with the Dwight-Lloyd sintering machines[2] which was traced to free S from the treatment of pyrite ore. It was found that the amount of S fume set free diminished as the air became warmer and dryer.

Continuous Tower Filter.—A continuous tower filter has been patented by G. Rigg[3].

Ammonia in Flue Dust.—This question, discussed last year by A. S. Dwight and J. W. Richards[4] receives a reasonable explanation by E. C. Hickman[5] who seeks the source of ammonia in the coke from which the volatile matter has not been completely eliminated. The burning of such a coke would be completed in the upper part of the blast furnace, and any ammonia present expelled. The ammonia would combine with sulphur trioxide to form sulphate which would be collected with the flue dust. In briquetting, the lime added as a binder would liberate the ammonia.

[1] MINERAL INDUSTRY, **20**, 487 (1911), with cross ref.
[2] MINERAL INDUSTRY, **22**, 469 (1913).
[3] U. S. Patent No. 1095076, May 5, 1914.
[4] MINERAL INDUSTRY, **22**, 473 (1913).
[5] *Eng. Min. Jour.*, **97**, 1260 (1914).

Electric Condensation.—W. H. Howard[1] describes with full details the electric fume precipitation at Garfield which is of as much interest to the lead as to the copper smelter.[2]

A discussion by E. M. Dunn[3] calls attention to the experimental work carried on at Anaconda where much larger volumes of gas have to be handled than at Garfield, requiring pipe condensers 3 ft. in diam. and 20 ft. long as against the 5-in. pipes 10 ft. long at Garfield. He also calls attention to the satisfactory results obtained at Anaconda with fractional precipitation, whereby the dust-laden arsenical fume from the Brunton furnaces is separated into dust and white arsenic of 99.5 per cent. As_2O_3 ready for the market.

F. G. Cottrell and Linn Bradley give the details of the various precipitation installations in a special article later in this volume.

Smelter Fume in the Salt Lake Valley is receiving much consideration. The two lead smelteries at Midvale and Murray use the Sprague process for neutralizing the SO_3 in the gases before these pass into the bag houses. The SO_2 content of the atmosphere in the valley averages 0.25 part in a million, ranging from a trace to 1 part. The harmful effect of this SO_2 upon vegetation is being studied on an experimental farm of 50 acres in charge of agricultural experts.

Report of the Selby Smelting Smoke Commission.[4]—The investigation on the smoke nuisance of the Selby Smelting and Lead Co., Valley Junction, Cal., was started in May, 1913, by a board of technically trained men and their report was submitted December 8, 1914. The conclusions arrived at are that the content of SO_2 in the gases passing off into the air averages less than 0.2 part per million of air, which is harmless to animal and plant life, and that since the installation of the bag house the amounts of lead and arsenic leaving the plant are infinitesimal. The technical details of the investigation ought to form a valuable contribution to the subject of condensation.

Lead Poisoning.—A most interesting report upon this subject has been prepared by Alice Hamilton,[5] which deals with the conditions prevailing at the leading lead smelteries and refineries of the United States and compares them with those existing in Europe. The indictment against our plants is severe, when it is considered that out of 7400 men employed in 1912 in 19 American works 1769 were lead-poisoned, while of the 2400 men of England only 56 were thus affected. This great difference is caused, of course, by the existence of effective laws in Great Britain and

[1] *Bull. Am. Inst. Min. Eng.*, Aug., 1914, p. 2029.
[2] See under PYROMETALLURGY OF COPPER..
[3] *Bull. Am. Inst. Min. Eng.*, Nov., 1914, p. 2738.
[4] *Min. Sci. Press*, **109**, 947 (1914); *Eng. Min. Jour.*, **98**, 1075 (1914).
[5] *Bull.* 141, *U. S. Bureau of Labor Statistics*, Washington, 1914, abstract, *Eng. Min. Jour.*, **98**, 179 (1914).

their proper enforcement. It is also shown that lead-poisoning is caused mainly through dust and smoke entering the body through the mouth and nose, and not, as is frequently held, by being absorbed through the skin. Of the different processes in operation, the ore-hearth has been proved to be the most harmful; in blast-furnace work the tapping-floor with its fumes is found to be more harmful than the feed-floor; the converting of lead matte rivals the ore-hearth in poisoning men; blast-roasting in Huntington-Heberlein pots has greatly increased the plumbism of men; the Dwight-Lloyd machines are less harmful than the pots, although some machines are so arranged as to make the cleaning of grate, etc., a very unhealthy operation. Handling of ores and by-products shows percentages of lead-poisoning which prove that the departments of receiving and sampling require as much attention as do those of smelting. The report describes the leading operations, gives photographs showing the harmful conditions under which the work is carried on, refers to the leading authorities in comparing the data collected, and gives in appendices some recent chemical researches on the subject, and the laws of England, France and Germany dealing with treatment of lead ores and the manufacture of lead products.

Sulphur Bug.—In a recent talk on smelting, C. W. Goodale[1] called attention to "sulphur bugs," insects which in Montana smelteries appear to thrive in hot sulphurous gases; a similar observation was made by E. Hall[2] in Queensland, where swarms of flies, green in color and of a size between a house-fly and a bee, swarmed in the hot gases of the Huntington-Heberlein pots.

Manufacture of White Lead from Galena.—R. A. Stuart[3] patented an apparatus for making white lead direct from ore which consists of an oil-fired revolving cylindrical roasting furnace delivering into a stationary oil-fired roasting furnace provided with staggered shelves, and a filtering chamber. A suction fan draws the gases through the three apparatus.

Wet Processes.—At the July meeting of the German Mining and Metallurgical Society[4] Büeler de Florin read a paper on the use of nitric acid for the leaching of ores. As regards lead, solution is expressed according to Kingsley by $3PbS + 8HNO_3 = 3Pb(NO_3)_2 + 2NO + 4H_2S + 3S$, and the regeneration of the solvent by $Pb(NO_3)_2 + Na_2CO_3 = PbCO_3 + 2NaNO_3$ and $2NaNO_3 + H_2SO_4 = Na_2SO_4 + 2HNO_3$; Rankin formulates solution by $3PbS + 8HNO_3 = 3PbSO_4 + 8NO + 4H_2O$, and regeneration by $2NO + 3O + H_2O = 2HNO_3$.

[1] *Eng. Min. Jour.*, **27**, 681 (1914).
[2] *Eng. Min. Jour.*, **98**, 80 (1914).
[3] U. S. Patent 1088041, February 24, 1914.
[4] *Metall und Erz*, **11**, 509 (1914); *Met. Chem. Eng.*, **12**, 583 (1914).

DESILVERIZATION

'attinson Process.—An improvement upon the Steam-Pattinson or -Rozan process has been patented by W. Thum.[1] The original inson process has a number of kettles to hold the intermediary prod-; the Luze-Rozan has a single crystallizing kettle and stores the in-ediary products in the form of large ingots on the floor; the Tredin-modification[2] goes back to the Pattinson idea of having a kettle for intermediary product, but instead of transferring liquid lead and tals by ladling, supports each kettle on a hydraulic ram so that it can ised or lowered to deliver lead to its neighbor or to receive from it. mode of operation, in use at Omaha,[3] demands a considerable outlay ost of plant. Thum transfers the contents of stationary kettles by ns of compressed air.

nternational Lead-refining Plant.—The new works of the Interna-l S. & R. Co. at East Chicago, Ind., are briefly described by H. P. Hulst.[4] have a monthly capacity of 5000 tons of lead bullion, running 25 . The site covers 64 acres, contains five storage tracks with space 00 cars, and a 100-ton track scale. The operations are carried on in a e building of steel and concrete 480 by 180 ft. and 50 ft. high; the -section shows two 15-ton electric cranes of 28 and 77 ft. span. bullion from Tooele (Pb 99.5 per cent., Ag 65 and Au 0.4 oz. per ton), h is not sampled, is delivered from the cars into the two water-jacketed ning furnaces (13 ft. 6 in. by 28 ft. 2 in. inside and 31 in. deep, hold-00 tons bullion and tapping 220) by means of a steam-driven Howe eyor; other bullion is unloaded into two 45-ton kettles, melted, drossed sampled and then run into the softening furnaces. There are two ton desilverizing kettles, one 300-ton reverberatory refining furnace one 200-ton reverberatory moulding furnace. Three residue furnaces, 16 ft. inside and 20 in. deep, serve for the treatment of copper dross antimony skimmings, of silver-bearing litharge, and of refining skim-gs. The bullion from furnaces Nos. 1 and 2 is tapped into pots, n by a crane to two liquating kettles of 60 tons capacity and stored. Saturdays the frozen bullion is liquefied, purified by blowing air igh it and drossed, and the dross pressed, leaving 0.5 per cent. Cu ie bullion. This is then pumped into the softening furnace and ed over Sunday, as, being hard, it requires more than the regular ir. given to softening. Two blast furnaces (42 in. in diam. at res by 14 ft. high, with five 3-in. tuyères) produce lead bullion and lead. One bag house, 50 by 65 by 50 ft., with 4 bays each containing

. S. Patent No. 1106480, August 11, 1914.
INERAL INDUSTRY, **9**, 457 (1900); **11**, 851 (1902); **16**, 689 (1907).
INERAL INDUSTRY, **17**, 605 (1908).
ull. Am. Inst. Min. Eng., Aug., 1914, p. 1865; Nov., 1914, p. 2749.

144 woolen bags, 18 in. in diam. and 30 ft. long, collects all the fume and dust; the bags are shaken mechanically; the gases are delivered by an 8-ft. American Blower Co. fan. The zinc-silver-lead crust is distilled in eight oil-fired furnaces with retorts holding a 1300-lb. charge; the retort bullion is cupelled in two tilting cupels of 5 tons capacity supported by Rhodes test carriages. The refined lead with 0.01–0.12 per cent. Bi goes either direct to the moulding furnace, or passes first to the Pattinson plant, if corroding lead with 0.05 per cent. Bi is to be produced. This plant has two 60-ton crystallizing kettles and four 20-ton heating kettles; one crystallization is sufficient to reduce the Bi content from 0.12 to 0.05 per cent. if the Hulst press is employed, otherwise two crystallizations are necessary. The recovery of Bi is not profitable.

Divine Process.—R. D. Divine[1] has devised a process of recovering as oxide the zinc contained in the refining skimmings obtained in freeing desilverized lead from the 0.6 per cent. zinc it retains. Usually the zinc is lost, as the skimmings are smelted in a blast or reverberatory furnace. The process, in operation at South Chicago, consists in crushing the skimming to ½-in. size, mixing with Na_2CO_3 and finely pulverized oil-coke, and smelting the mixture in a reverberatory furnace on a bath of lead, when lead and antimony are taken up by the metal, while the zinc is volatilized, oxidized and collected in a bag house; the resulting slag (soda skim) is removed and smelted in the blast furnace. The zinc oxide is refined at Omaha by the Hall process, which precipitates electrolytically very pure zinc from a sulphate solution.

At South Chicago, air is blown through the bath of desilverized lead to hasten the refining. At first mainly zinc is oxidized; blowing is continued until most of the zinc has been removed; the blast is shut off, and the skimming formed (Zn 16.50, Pb 63.50, Sb 6.00 per cent.) drawn off. The temperature is now raised, air blown again through the metal to oxidize the small amounts of Sb present to antimoniate of lead which is held in solution with the remaining ZnO by the litharge formed at the same time. It contains Zn 65.00, Pb 14.65, Sb 1.00 per cent., is drawn off, and goes with the desilverized antimony skimmings from the softening furnace to the blast furnace to be smelted for hard lead. One ton of zinc skimming, containing 17–18 per cent. ZnO, is crushed to 0.5 in. and mixed with 175 lb. soda ash and 400 lb. coke; a charge of 18 tons is smelted in 24 hr.; the furnace is oil-fired, as it is essential for success that the temperature be kept constant when it has reached the point at which the reaction starts, which is about 1000° C. The soda skim formed, 10–15 per cent. of the weight of the charge, contains Zn 24.50 and Sb 9.8 per cent., and goes to the hard-lead furnace. There is

[1] *Bull. Am. Inst. Min. Eng.*, August, 1914, p. 1877.

recovered from 80 to 85 per cent. of the zinc contained in the skimming. The rôle that Na_2CO_3 plays in the process is not quite clear; that its addition is essential is shown by the fact that charges worked without it gave a recovery of about 10 per cent. of the zinc.

Retorting Furnace.—The Morgan Crucible Co., Ltd.,[1] has patented[2] a pear-shaped horizontal retort for distilling zinc crusts which is enclosed in a tilting furnace. The improvements on the usual arrangement consist in having a planed metal ring enclosing the throat of the retort which forms the support of the condenser, and a condenser made up of two parts, one for collecting the zinc, the other for carrying off the condensed vapors and the gases.

Distillation of Crust.—Laboratory experiments by Clevenger[3] have been carried out with distillation for the recovery of zinc from cyanide precipitate, which bring out some features applicable to the retorting of zinc crusts. The precipitate had the composition Au 16.639, Ag 23.166, Fe 0.170, Al 0.800, Ca 6.680, Mg 0.070, Zn (as metal) 14.510, Zn (as oxide) 18.060, Pb 0.730, Cd trace, Cu 0.870, Mn 0.100, SiO_2 1.760, S 0.210, CO_2 3.770, difference (CN, O, etc.), 12.465 per cent. It was mixed with test lead and charcoal, and with charcoal alone, placed in a graphite crucible provided with prolong, and heated, making time and temperature the variables. The results show that between 1100 and 1200° C. there is expelled an increasing percentage of zinc ranging from 6 to 90 per cent., and between 1200 and 1300° one from 90 to 100 per cent. As regards time, the amount required for satisfactory expulsion is small as long as the temperature has been brought to the required height.

Cupellation.—C. H. Mathewson and C. H. Stokesbury[4] have investigated the system Ag-Cu_2O. They find that Cu_2O is readily soluble in Ag when molten, and practically insoluble when solid. The freezing-point curve shows a eutectic point at 945° C.; the eutectic is composed of Ag 98.7 and Cu_2O 1.3 per cent. A comparison of calculated values with those obtained by experiments indicates that dissolved Cu_2O is either dissociated or reacts upon Ag as shown by $Cu_2O + 2Ag \rightleftarrows 2Cu + Ag_2O$. An Ag-Cu alloy with little Cu melted and allowed to solidify in air shows that the Cu occurs as Cu_2O between grains of Ag; hence, the Cu in all cupelled silver must be present as Cu_2O and not as Cu as has been supposed.

Electroplating.—F. C. Mathers and B. W. Cockrum[5] have given the results of their work on the electrodeposition of lead from acetate and formate solutions, to which the reader is referred.

[1] *Metall u. Erz*, **10**, 950 (1913).
[2] German Patent No. 266751.
[3] *Eng. Min. Jour.*, **98**, 109 (1914).
[4] *Internat. Zeit. Metallographie*, **5**, 193 (1914).
[5] *Trans. Am. Electrochem. Soc.*, **26**,— (1914); *Met. Chem. Eng.*, **12**, 714 (1914).

Betts Process.—T. A. Patterson[1] furnishes experimental data upon the electrical conductivities of fluosilicic acid and lead fluosilicate. He finds that the conductivity of the acid falls quickly with the decrease in acid and rises slowly with the temperature, and that it falls slowly with the decrease in salt. The normal acid contains 7.2 per cent. H_2SiF_6; the normal salt has the formula $PbSiF_6 + 4H_2O$.

W. Thum[2] has patented a process for the purification of Cu-bearing Bi obtained in the electrolytic refining of lead bullion by means of the Betts process. The Cu-bearing Bi is crushed, mixed with salt cake and coke breeze to the amount of 2½ times the quantity required by the chemical formulæ, charged into a cupelling furnace and melted. The fused mass consists of three layers, soda slag, copper matte and bismuth; gold and silver are collected mainly in the Bi, but some goes into the matte. The slag and matte are raked off, and the Bi cast into anode bars to be refined electrolytically, if it contains less than 1 per cent. Cu. If it contains over 1 per cent. the Bi is cupelled and the liquid Bi_2O_3 floating on the surface is drawn off, as litharge is ordinarily, and retreated. The cupellation is stopped when only little Bi remains and the remaining Au-Ag-Bi alloy refined independently.

[1] *Met. Chem. Eng.*, 10, 670 (1913).
[2] U. S. Patent No. 1098854, June 2, 1914.

LITHIA

By Victor Ziegler

of very minor importance, its uses being so few and of such not to afford an active market. Formerly lithium carbonate n product, and this was used in the manufacture of artificial ters and for other medicinal purposes. The product was d in cases of rheumatism. A small amount is also used in d some lithium bromide is used in photography and medicine. e of lithia at present is in the form of lithium hydrate in elec- batteries. Nothing appears to be known of the exact action m hydrate beyond the fact that its presence prolongs the life ry.

small traces is present in almost all rocks but is more charac- da-rich acidic igneous rocks and especially pegmatites. The of lithia are the minerals lepidolite, spodumene, lithiophylite, nd amblygonite. Lepidolite, the alumino-silicate of lithia, tash, is also known as lithia mica, and lithionite. Its lithia ies up to 4.2 per cent. It occurs in micaceous aggregates in color from colorless into pink, yellow, green and brown but a shade of lavender or lilac. Caesium and rubidium are ound in such lepidolite. It usually occurs in irregular shoots ften of great size. Before 1886, Saxony and Bohemia were ducers of lepidolite, but in that year the amblygonite deposits as, in central France, were discovered and these soon became ducers in Europe. About 1900 the pegmatites of San Diego lifornia, attracted attention and for several years furnished lred tons of lepidolite annually, which were shipped to Europe t. At present no lepidolite is used for lithia extraction. The of South Dakota contain several pegmatites rich in lepidolite, lso prominent in similar pegmatites in Maine, Massachusetts ticut.

resent time, amblygonite furnishes all the lithia produced, by ter proportion coming from the Black Hills. This mineral ate of lithia and alumina and because it yields to cheaper nd gives more valuable by-products, makes the treatment lithia minerals unprofitable. For some time pegmatites near

Montebras, France, yielded amblygonite, but these deposits seem to be practically exhausted. A few hundred tons was produced in California in San Diego County, near Pala, but there has been no production here for a number of years. Amblygonite was also discovered in the San Finx tin mine in Spain, and in northern Australia. The latter district produced 45 tons in 1906, but nothing since as far as known.

The Black Hills deposits are actively worked at present, the chief producing mines being the Peerless and the Hugo near Keystone. The amblygonite occurs in nodules, often of great size, but restricted in occurrence to shoots and pockets in the pegmatites. Individual nodules up to 1000 lb. in weight are common. One shoot of solid amblygonite exposed in the Hugo mine measured 15 by 22 by 40 ft. The deposits are worked by open-cut methods. The total production for 1913 was in the neighborhood of 500 tons, while the total production of the Black Hills deposits up to 1914 is about 3000 tons. The amblygonite is shipped to Newark, N. J., where it is treated by the Standard Essence Co.

There have been no developments of importance during 1914. No new deposits have been discovered. Some prospecting for amblygonite has been done in California during the past year, but none was found in commercial quantities. South Dakota continues to be the only producer. Amblygonite only was produced, and nearly all came from the Keystone district. The Hugo mine, the only important producer, was shut down during the winter of 1914–1915. Work was resumed in May 1915. The production for 1914 was about the same as the preceding year, totalling about 500 tons.

A detailed and illustrated description of the South Dakota deposits is given in "The Lithia Deposits of the Black Hills," *Eng. Min. Jour.*, Dec. 6, 1913.

MAGNESITE

p to the present the United States has been dependent largely upon gn sources for its supply of magnesite or carbonate of magnesia, the rts in 1913 amounting to 172,591 short tons, as compared with only tons produced in this country. It is interesting to note that the r portion of the imports (163,715 short tons) came from Austria-gary, and that most of the remainder came from Greece, and was d for calcining at Hamburg and Rotterdam before being re-shipped is country. In 1914 the domestic production amounted to 11,293 and the imports to 120,583 tons. The question of the adequacy of ie domestic supply to meet our needs therefore assumes much rtance.

he dependence of American users of magnesite on the foreign supplies e for one thing to the location of the American depostis in California, great a distance from the eastern markets that the freight rates been prohibitive. The establishment of water transportation gh the Panama Canal may be expected to alleviate this difficulty. ond cause is the difference in composition between the magnesites ustria-Hungary and those of California. The former generally in 6 to 8 per cent. of iron, which appears to be beneficial in the ufacture of refractory brick.

ith the cutting off of the Austro-Hungarian and possibly of the an supplies there would seem to be every reason why the California try should be materially advanced. Fortunately the deposits in state are numerous, and many of them are fairly large and of high . In the opening and development of these mines their nearness ilroad transportation seems to have been of more importance than haracter or extent of the deposits. Certain deposits, notably in a Clara and San Benito Counties, are known to be large in extent f good character of material, but they lie idle, owing to the distance nineral must be hauled to a railroad, while smaller mines close to ad stations are being worked.[1]

alifornia (By F. McN. Hamilton).—Magnesite has for a number of been known to exist in many localities in California. In quality very high grade, many deposits yielding products carrying about 95 ent. magnesium carbonate. The deposits are mostly in the meta-

. 599, U. S. Geol. Surv.

morphic rocks of the Coast Range and Sierra Nevada Mountains, and are scattered over an area nearly 400 miles long. One deposit of sedimentary origin is situated in the Mojave Desert region.

STATISTICS OF MAGNESITE IN THE UNITED STATES
(Tons of 2000 lb.)

Year.	Production. (a)		Imports.		Total.	
	Tons.	Value.	Tons.	Value.	Tons.	Value.
1902.....	2,830	$8,490	49,786	$373,928	52,616	$394,583
1903.....	3,744	10,595	54,776	461,399	56,137	481,914
1904.....	2,850	9,298	38,704	286,828	41,554	296,126
1905.....	3,933	15,221	74,374	638,619	78,307	654,840
1906.....	7,805	23,415	90,396	863,492	94,428	903,812
1907.....	7,561	22,683	99,008	875,359	105,413	933,079
1908.....	6,587	19,761	84,494	736,763	93,461	789,105
1909.....	9,465	37,860	114,292	985,019	122,234	1,047,607
1910.....	12,443	74,658	170,327	1,542,800	178,327	1,602,580
1911.....	9,375	75,000	122,420	1,114 520	144,449	1,253,297
1912	10,512	84,096	125,481	1,266,375	149,657	1,479,665
1913.....	9,632	77,056	167,583	1,669,300	177,565	1,746,356
1914.....	11,293	124,223	120,583	1,297,835	131,876	1,422,058

During the year 1914 there was considerable activity in the production of magnesite, giving a larger output than during any previous year except 1910. Doubtless the curtailing of some European supplies, due to the war, and the added facilities for transportation, through the Panama Canal, to Eastern markets, have led to the increased production. The permanent nature of improvements at some deposits gives promise that future production will be still greater. The principal uses have in the past been for refractory furnace-lining, and for the manufacture of paper from wood pulp. Future efforts by manufacturers should enlarge the use of magnesite in structural work. With proper methods, excellent flooring and other interior finish can be made, but it appears that experimentation and standardization of products will be necessary in order to insure uniformly satisfactory results.

Four counties contributed to the production as follows:

Alameda	150 tons
Santa Clara	425 tons
Sonoma	4,600 tons
Tulare	9,600 tons
Total	14,775 tons (2000 lb.)

Some of the smaller deposits ship the crude product and receive a price of about $5 per ton. Where it is calcined, the price varied from $25 to as high as $40 per ton. About 2½ tons of crude produce 1 ton of calcined.

The following concerns are among those producing in 1914:

Cedar Mountain Magnesite Mine, which mines the rock by the glory-hole system, and calcines in a flat hearth furnace, using oil fuel and having a daily capacity of about 10 tons of crude.

The Sherlock Mine quarries the rock and ships it in the crude state.

The Sonoma Magnesite Co. is installing rotary kilns and a short railroad for delivery to the main line.

The Tulare Mining Co. stopes the magnesite exposed in underground workings, and calcines the product.

A number of owners have carried on development work, and it seems assured that a much greater demand can easily be met by the various California deposits.

Prices[1]

The price which has been paid for domestic magnesite has varied from $16 per ton on contract for large quantities f.o.b. rail at the point of shipment, to as high as $50 for small lots of a ton or two ground and packed in barrels at San Francisco. Normally the price for carload lots unground in bags is $25 to $30 per ton and $40 per ton for the ground product in barrels. Light burned magnesite has been recently offered for local consumption, ground, in barrels, at $35 per ton f.o.b. San Francisco. At the outbreak of the war, Chicago consumers of light burned magnesite offered to contract for 1000 tons, unground, in barrels weighing 300 to 400 lb., at $33.50 per ton. f.o.b. rail California. Some European product is again coming into this country, and somewhat lower prices prevail. Quotations f.o.b. New York are now from $30 to $35 per ton.

IMPORTS OF MAGNESITE INTO THE UNITED STATES
(Fiscal year ending June 30)

	1912.		1913.		1914.	
	Pounds.	Value.	Pounds.	Value.	Pounds.	Value.
Magnesia:						
Calcined	101,106	$16,326	72,579	$12,592	109,859	$15,118
Carbonate	60,904	2,727	77,190	3,811	58,683	3,972
Sulphate	10,703,209	41,739	9,345,099	35,739	13,549,599	48,742
Magnesite:						
Calcined, not purified	241,503,372	1,265,339	345,322,155	1,731,443	288,989,577	1,485,273
Crude	35,810,752	104,326	33,654,260	111,276	21,590,605	46,611

Foreign Countries

Austria-Hungary.[2]—The beds in which magnesite is found in Austria and Hungary follow more or less a northeast and southwest line that would about cross between the cities of Vienna and Budapest. The valleys of the Danube and its tributaries divide these deposits into two groups. The Austrian group extends across the province of Steiermark, with its western extremity near the city of Salzburg and its farthest eastern deposit near the town of Gloggnitz. The biggest deposit in this group is

[1] S. H. Dolbear, *Min. Press*, Jan. 16, 1915.
[2] L. C. Morganroth, *Bull. Amer. Inst. Min. Eng.*, 93, 2345 (1914).

near the town of Veitsch. The Hungarian deposits have their western extremity near the village of Divin; the eastern extremity is not clearly defined and may extend into Russia. The largest deposits in Hungary are midway between the towns of Jolsva and Nyustya. The magnesite occurs only in isolated lenses, and while some of these lenses are very large, many are too small to be worked profitably. It is probable that commercially workable deposits in Austria and Hungary do not exceed a dozen in number.

THE PRINCIPAL SUPPLIES OF MAGNESITE
(In metric tons)

Year.	Austria-Hungary. (a)		Greece.		India. (d)	United States. (d)
	Crude	Calcined	Crude	Calcined		
1901	.....	40,236	20,348	.....	(e)	4,286
1902	.....	53,467	23,020	.....	3,597	2,567
1903	.....	69,058	28,415	.....	838	1,234
1904	.....	53,781	9,133	.....	1,193	2,585
1905	.....	92,359	37,063	.....	2,645	3,568
1906	.....	87,765	40,584	.....	1,861	7,093
1907	452	113,695	55,816	.....	188	(f) 6,858
1908	212	87,049	63,079	.....	7,655	(f) 5,994
1909	1,027	125,666	56,797	16,609	199	(f) 8,588
1910	341	182,911	18,073	19,982	5,264	(f) 11,291
1911	77	182,911	86,956	27,530	3,546	(f) 8,505
1912	.....	171,196	106,338	33,848	15,626	(f) 9,534
1913	.....	200,947	23,269	29,216	16,468	(f) 8,741

(a) Exports. (d) Crude magnesite. (e) Not reported. (f) U. S. Geol. Surv.

The Veitsch deposit is a huge lens found in an isolated hill surrounded on all sides by barren rocks. It is on the outskirts of the village of Veitsch, which is about 65 miles southwest from Vienna. The entire top of the hill is magnesite. From the top to the base of the magnesite is from 700 to 800 ft., the bottom of the magnesite being about half way down the hill. The quarry is worked in a series of steps or levels about 50 ft. apart vertically.

The material is blasted out of the solid in the ordinary manner of rock quarrying. The magnesite is broken to one-man pieces, or less, and any particles of dolomite and quartz carefully sorted out. In the best deposits there is always a large amount of this gangue. The magnesite, loaded on tram cars, is lowered by gravity planes to the base of the hill, where the works are situated. Here it is burned in continuous kilns of the bottle variety. These kilns burn on the average 12 to 15 tons in 24 hr. As a rule, producer gas is used as fuel. Within the last few years several plants have installed kilns of the rotary type to burn the magnesite, powdered coal being used as fuel. The capacity of these rotary kilns is probably 50 to 60 tons in 24 hr. The magnesite can be burned as thoroughly in these kilns as in the bottle kilns, but they have one disadvantage, in that a larger percentage of fines is produced.

Canada.[1]—Magnesite occurs in a limited area in the township of Grenville, P. Q. It is found associated with serpentine in pyroxenites and crystalline limestones. One firm is operating a deposit of fairly good dimensions, and has installed a calcining kiln and grinding plant at Calumet, on the north shore of the Ottawa River. The mineral is of good quality, as the accompanying analyses will show:

	Crude Magnesite.		Calcined Product.
$MgCO_3$	84.50	MgO	74.84
$CaCO_3$	15.00	CaO	10.84
Fe_2O_3 and AL_2O_3	0.27	Fe_2O_3 and Al_2O_3	1.20
Insoluble	0.62	Insoluble	2.62
		Lost through calcination	10.40
	100.62		100.00

Other analyses are:

	1.	2.	3.	4.
Carbonate of magnesia	81.27	95.55	85.00	77.07
Carbonate of lime	13.64	.....	10.80	16.28
Magnesia other than carbonate	3.66	.....	.....	3.22

One average over the body, 500 ft. by 60 ft. wide, gave:

Silicon	0.25
Carbonate of lime	11.43
Carbonate of magnesia	86.60
Magnesia in other forms	2.05
	100.34

The product shipped has averaged:

Carbonic acid	49.85
Magnesia	44.20
Lime	5.15

There is every possibilty that the district contains other workable bodies than those now operated, and float magnesite has been found over a wide area.

The only other points in the Dominion at which magnesite is found are the Atlin Townsite, Y.T., and the vicinity of 108-mile house, on the Cariboo Road, 93 miles north of Ashcroft, in the Lilloet District. The mineral in both these cases is a hydromagnesite, and while the first-mentioned case is but a small deposit, the Cariboo body is very extensive and may some day become of great importance.

Greece.[2]—The production of Greek magnesite is mainly in the hands of three companies: the Anglo-Greek Magnesite Co., 24 Finsbury Square, London; the Société Helleninque des Mines, and the Hellenic Magnesite Co., both with headquarters at Athens. The distribution of this magnesite, however, is controlled by the first-named company.

The Anglo-Greek Magnesite Co. (Ltd.) operates mines at Galataki and Afration, near Limni, Eubœa. At the Galataki mines the vein of ore exploited is known to be 1300 ft. long and 50 to 60 ft. thick. The

[1] *Min. Jour.*, Jan. 23, 1915.
[2] *Daily Cons. & Tr. Rept.*

ore is transported by a 4½-mile aerial railway, run by a 15-h.p. steam engine, to Katounia, near the shore. At Katounia the different qualities of ore are segregated and are either exported in their natural state or undergo treatment in the seven gas ovens there. The output of each of these ovens reaches 10 tons of calcined and 4 to 6 tons of dry-kilned magnesite per day. At the Afration mines a vein 1140 ft. long and 10 to 16½ ft. thick is worked, and the ore transported to the ovens by a Decauville wire railway.

The Société Hellenique des Mines (now called the Financial Corporation of Greece, Ltd.), lately leased the Société des Travaux Publics et Municipaux and the Société Metallurgique Boeotia, and now controls the production of mines at Mantoudi, Limni, Larimna, etc. The area owned by this company is 23,850 acres, and the principal mines operated by it are at Elafrosouvala, Koufala and Gerorevma. The Elafrosouvala vein ranges in thickness from 3 to 50 ft.; part of the ore of this mine is transported over a 23½-in. gage railroad to the Kymassi shore, where it is loaded into ships. The remainder of the ore is calcined in the ovens of the company at Fourni (whither the ore from the Gerorevma and Platoria mines is also sent), the equipment at this place consisting of one Schamatola oven for making calcined magnesia and a Mendheim 16-compartment oven for producing calcined magnesite and magnesite bricks.

The Hellenic Magnesite Co. obtains most of its ore from surface excavations near Aghia Triti, Eubœa, where the magnesite is found in talc schist veins. The ore is carried by a Decauville aerial railway to Pyli, 4 miles distant, where it is loaded into ships for exportation or stored for treatment in the 17 ovens there.

Norway.—A distinct type of magnesite is found in Norway, near the town of Snarum. It occurs as small veins in serpentine, but unlike other magnesite in serpentine, it is crystalline. The crystals are small and uniform in size and are distinctly different from the crystalline variety of Austria-Hungary. It is white, or tinged green or yellow from the particles of serpentine which are more or less intimately mixed with the magnesite. At present there is only one deposit worked, and this in a very small way. It is doubtful, if they will ever amount to much commercially, on account of the limited amount of magnesite of good quality.

In Sweden similar deposits are found. On account of their situation, operating and transporation charges would be excessive, and it is doubtful if they will ever be able to compete with the much cheaper magnesite of Austria-Hungary.

USES[1]

The highly refractory quality of magnesite and its ability to form a hard vitreous body when combined with magnesium chloride, has led to its adoption for a large number of purposes. The largest consumption is in the manufacture of magnesite firebrick, crucibles, and in bedding steel furnaces. As magnesium bisulphite it is used extensively in digesting and whitening wood pulp in paper mills. It is used in a mixture with sand, sawdust, ground quartz, talc, and other substances, in the manufacture of tile, plastic flooring, roofing, sinks, wainscoting, in scagliola or artificial marble, and on the exteriors of buildings as a plaster. The manufacture of so-called "cold water" paints and concrete water-proofing also involves the use of magnesite with $MgCl_2$. It also enters into a preparation for insulating boilers and steam pipes, mixed with such substances as asbestos and infusorial earth. It has been introduced into boilers to prevent scale when sulphurous water is used.

Much magnesite was formerly burned for the double purpose of securing a calcined product and to recover the carbon dioxide content. The reason which led to a discontinuance of this practice was that efficiency in the production of one product was had at the expense of the other. For several years limestone has taken the place of magnesite, although recently attempts have been made at a carbonic-gas plant situated at Berkeley, Cal., to revive the practice.

[1] S. H. Dolbear, *Min. Press*, Jan. 16, 1915.

MANGANESE

By James Aston

As a producer of manganese ore of high grade, the United States has remained practically a negligible factor. Production in 1914 amounted to 2635 long tons, according to the United States Geological Survey, as compared with 4048 tons in 1913. The primary interest of this country is, therefore, in such foreign supplies as are available for our uses, essentially in the manufacture of ferro-manganese, and in the importations of the ferro-alloy to supply our additional needs. The latter roughly averages about half of the total requirement.

In view of the dependence of the United States upon foreign supplies, and particularly since the greatest proportion is obtained from countries involved in the war, it is but natural that the ferro-manganese situation became a topic of absorbing interest to the steel maker. Great anxiety prevailed in the last half of the year, and it was only the combination of accumulated stocks in the first half-year and the depression in the steel industry that prevented conditions from becoming calamitous.

The total ore production of the United States is shown in the following table:

PRODUCTION OF MANGANESE ORES IN THE UNITED STATES (a)
(Tons of 2240 lb.)

Year.	Manganese Ores.				Manganiferous Iron Ores.				Man. Zinc Ores.	Total Production.	
	California.	Georgia.	Virginia.	Other States.	Arkansas.	Colorado.	Lake Superior.	Va. & N. C.	New Jersey.	Long Tons.	Value.
1901.	610	4,074	4,275	3,036	*Nil.*	62,385	512,084	20	52,311	638,795	1,644,117
1902.	846	3,500	3,041	90	*Nil.*	13,275	884,939	3,000	65,246	973,937	2,145,783
1903.	16	500	1,801	508	*Nil.*	14,856	566,835	2,802	73,264	660,582	1,670,349
1904.	60	*Nil.*	3,054	32	600	17,074	365,572	*Nil.*	68,189	454,581	789,133
1905.	1	150	3,947	(e) 20	3,321	45,837	720,090	*Nil.*	90,289	863,655	1,681,472
1906.	1	.....	6,028	892	8,900	32,400	1,000,008	*Nil.*	93,461	1,141,690	(e)3,403,993
1907.	100	*Nil.*	(d)4,604	900	4,133	(d) 99,711	(d) 314,316	*Nil.*	93,413	517,177	1,510,156
1908.	321	*Nil.*	(e)6,144	200	(d) 4,066	(d) 51,524	(d) 467,140	274	110,225	639,894	1,280,989
1909.	3	*Nil.*	1,334	*Nil.*	(d) 3,325	(d) 65,024	(d) 775,035	305	141,264	986,290	2,209,461
1910.	(f)	*Nil.*	2,059	199	(d) 5,030	(d) 55,770	(d) 558,634	301	137,173	759,166	1,938,429
1911.	(f)	*Nil.*	(g)2,457	*Nil.*	(d)2,177	(d)41,753	477,920	507	109,296	634,110	1,386,464
1912.	(f)	*Nil.*	(g)1,664	*Nil.*	(d) 1,332	(d) 48,618	816,984	1,567	104,670	974,835	1,982,00
1913	(f)	*Nil.*	(g)4,048	*Nil.*	(d) 9,650	(d) 49,753	(d) 612,743	(f)	(d) 102,239	778,433	.....
1914.	(f)	*Nil.*	(g)2,365	*Nil*	(h)	(h)	(d) 445,827	(h)			

(a) Statistics of 1900–1906 are by the U. S. Geological Survey. (b) Includes 1300 tons of manganiferous iron ore from Vermont. (c) As reported by Virginia Geological Survey. (d) As reported by U. S. Geological Survey. (e) Estimated. (f) Figures not available. (g) Includes Tennessee and California. (h) Included under Lake Superior.

Below are listed the statistics of United States production of ferro-

manganese and spiegeleisen, and our importations of manganese ore and ferro-alloys for the past 10 years.[1]

UNITED STATES PRODUCTION AND IMPORTS
(Long tons)

	Ore Imports.	Ferro-manganese.			Spiegeleisen.	
		Imports.	Av. Value per Ton. (a)	Production.	Imports.	Production.
1905	257,033	52,841	$35.67	62,186	55,457	227,797
1906	221,260	84,359	58.72	55,520	103,267	244,980
1907	209,021	87,400	61.27	55,918	48,995	283,430
1908	178,203	44,624	41.70	40,642	4,579	111,376
1909	212,765	88,934	38.19	82,209	16,921	142,831
1910	242,348	114,228	37.99	71,376	25,383	153,055
1911	176,852	80,263	37.56	74,482	20,970	110,236
1912	300,661	99,137	39.41	125,378	1,015	96,346
1913	345,090	128,070	44.37	119,496	77	106,980
1914	283,294	82,997	41.33	100,731	2,870	76,625

(a) At foreign port, no freight or duty.

The marked decline in spiegeleisen is noteworthy; in general because of the ascendency of basic open-hearth steel practice, and in importation because of this fact coupled with the heavy transportation charges per unit of manganese.

United States imports of ore were 163,390 gross tons for the period from Jan. 1 to Aug. 1, 1914, or at the rate of 23,341 tons per month. For the war period from Aug. 1 to the close of the year, imports were 119,904 tons, or 23,980 tons per month. The monthly average for the year was 23,608 tons, compared with 28,757 tons for 1913.[2] The real effect of the war conditions is not reflected in these figures, since there was a rush to accumulate stocks at the beginning of the war, and some surplus ore was available by diverting to this country cargoes consigned from Russia and India to Germany. With the entrance of Turkey into the struggle, and the isolation of the Black Sea, supplies from Russia ceased, and the British embargo upon shipments of ore from India, announced in October, left only Brazil as an available source of supply. Imports fell from 39,836 tons in October to 1761 tons in November, but rose to 26,243 tons in December. During 1913 ore supplies from the above countries were: India 141,587 tons, Russia 124,337, Brazil 70,200 in 1914, India 103,583, Russia 52,681 and Brazil 113,924 tons.

The ore situation is of less concern to the independent steel maker than that with respect to ferro-manganese, since the United States Steel Corporation, and particularly the Carnegie Steel Co., is the all-important domestic producer of ferro, and this almost entirely for its own needs. Production by other interests is spasmodic, although there has been a revival of activity because of the trade situation.[3] On Aug. 5 the

[1] *Steel & Metal Digest*, Mar., 1915.
[2] *Iron Age*, Mar. 4, 1915
[3] *Iron Age*, Sept. 3, 1914.

Carnegie Steel Co. announced the following schedule of prices for domestic ores, per gross ton delivered at Pittsburgh or South Chicago: 49 per cent. Mn, 26 cts. per unit; 46 to 49 per cent., 25 cts.; 43 to 46 per cent., 24 cts. This is an advance of 1 ct. per unit over the last schedules announced in MINERAL INDUSTRY for 1913. The above prices are based upon ores of not more than 8 per cent. SiO_2 or 0.20 P, and are subject to penalties for excess, up to the rejection limits. The latter are 40 per cent. Mn, 12 per cent. SiO_2, and 0.225 P on dried samples.

Other interests than those of the Steel Corporation are to a large degree dependent for their supplies of ferro-manganese upon importations, of which, previous to the war, about 90 per cent. was from England and 10 per cent. from Germany. Imports for 1914 were 82,997 tons, compared with 128,070 for 1913, a decrease of 45,853 tons, or 35 per cent. For the first 9 months of the year imports were 62,333 tons, or at the rate of 6926 tons per month. Importation in October was at a high rate, but with the declaration on Nov. 8 of the British embargo on shipments of ferro-manganese to the United States, importation practically ceased in November and December.

While the effect of the embargo caused but little concern among steel makers at the close of the year, since in general good stocks had been accumulated and the production of steel was at a low rate, the curtailment of shipments will certainly result in a pinch if there is a material revival of steel manufacture. Negotiations were under way at the close of the year to have shipments resumed, and with fair prospect of success, since the embargo was primarily aimed at re-exports of ferro from the United States to enemies of England; and it is expected that guarantees against such re-export of ferro-manganese, or of steel into which it enters, will result in a lifting of the embargo.

The year was productive of most extraordinary developments in the ferro-manganese market. Prices sagged from $45 seaboard, at the close of 1913, to $35 in the latter part of January, this being the lowest level since 1905. There was a break in the syndicate arrangements of English makers, and a vigorous selling campaign resulted in sales of sufficient tonnage to cover the needs of buyers for what proved to be a greater period than the balance of the year, because of the decline in steel production. The sales were made at $35 to $37 seaboard. By the early part of February, the market resumed a more normal condition with the subsiding of the buying movement, and prices steadied at $38. This figure was fairly well maintained until the last of July, when the outbreak of the war caused the withdrawal of all quotations. A period of great uncertainty and panicky conditions followed, and some sales were reported at $140 seaboard.[1]

[1] *Iron Tr. Rev.*, Jan. 7, 1915.

djustments of practice to use spiegeleisen were made in many nd sales of large tonnages of this alloy were made by the principal c producer. Prices of domestic spiegel advanced about $5 per 30, furnace, for 19 to 21 per cent., and $28 for 17 to 19 per cent. l.

ouncement of English producers in August that shipments of anganese would be resumed on contracts upon certain stipulated ns restored order in the market. With the market at $100, the orporation became a seller, and the result was a cut by English in September to $80. Re-sale ferro-manganese began to appear narket, and these facts, together with the small volume of business, prices down, in early October, to a formal quotation of $68, and even lower figures. Actual sales for re-export to certain foreign s, and fear by England that more would be made to her enemies, in the declaration of an embargo on Nov. 8.

rage monthly prices for ferro-manganese at eastern seaboard for 3 years have been as follows:

	1912.	1913.	1914.
.....	$41.00	$65.00	$36.00
.....	41.00	65.00	38.00
.....	41.00	65.00	38.00
.....	43.50	65.00	38.00
.....	47.50	61.00	38.00
.....	48.00	61.00	37.50
.....	49.50	58.50	37.50
.....	52.00	56.00	100.00
.....	55.00	55.00	80.00
.....	59.00	50.00	66.00
.....	61.00	50.00	68.00
.....	65.00	45.00	68.00

Carnegie Steel Co. and the Illinois Steel Co. are the only regular of ferro-manganese in the United States, and their product is not n sale in the open market, although in the latter part of the year eported that the former company had entered the market as a The American Manganese Manufacturing Co., the organiza- which was reported in MINERAL INDUSTRY for 1913, started one acks at Dunbar, Pa., on Oct. 14, to make ferro-manganese of 18 er cent. Mn from the company's Cuyuna-Mille Lacs mine in ta. Enough ore was in stock to produce 25,000 tons of product, two stacks of the company are able to make 150,000 tons yearly, d. At the close of the year Jones & Laughlin began operating their Alequippa furnaces on ferro. Ores were obtained from n the fall. The furnace, of 500 tons pig-iron capacity, will be make 100 tons per day of ferro-manganese, and in 3 months

can make the company's capacity requirement of 10,000 tons of ferro yearly.

The Noble Electric Steel Co., in northern California, is making ferro-manganese in its electric pig-iron furnaces from ores mined in that state.

Production of spiegeleisen for 1914 was 76,625 tons, chiefly in Pennsylvania, from manganiferous by-product remaining after the recovery of the zinc content of the New Jersey franklinite ores. There was some interest by steel works in the use of spiegel as a substitute for ferro-manganese, but this will be difficult except for heats of higher carbon, since the carbon in the two alloys is about the same, and there will be trouble in introducing the necessary manganese into soft steel by means of spiegel, and at the same time holding the carbon within limits.

The dependence of the steel industry of this country upon foreign sources of manganese has attracted attention to possible domestic supplies, and there has been considerable activity in exploration and development. Although there are numerous deposits of these ores in the United States, most of them are too small to furnish a large and regular supply, or average too low in manganese for the larger deposits, or are too inaccessible or remote to warrant development in the face of competition with the ordinarily plentiful supplies of high-grade material from Russia, India, and Brazil.

The Virginia deposits will probably be exploited to the greatest extent, since the question of transportation places them above other prospects in the south and west. This state formerly produced considerable quantities of high-grade ore, with a maximum output for any one year of 20,567 tons in 1885. Since then there has been a marked decline, with considerable variation in the annual figures. All of the 4048 tons of manganese ore reported as the domestic output in 1913 was from this state, and represented the largest production since 1908.

Deposits in Page and Rockingham Counties are reported to be of promise. Trench and pit prospects show mineral of high grade, low in silica and iron, and heavy enough to secure ready concentration by separation of the gangue.[1]

Investigations and negotiations have been conducted, but in general there have been no purchases of former small producing properties at the prices asked by the holders. The most important negotiation was in connection with the famous Crimora deposit in Augusta County. Sale was made to a New York company called the Crimora Manganese Corporation. It is proposed to open for large operation, using new methods to separate the ore from the clay. This deposit was formerly

[1] *Min. Eng. World*, Oct. 17, 1914.

one of the best producers and supplied the Carnegie Steel Co. with a large part of its requirements for many years. It has been closed for several years, since the expiration of the Carnegie lease.[1]

The Piedmont deposit, near Lynchburg, is being re-opened. Good ore was made available by development work of the holding company which failed last year. The property is now in control of new interests.

A Philadelphia syndicate has uncovered a large body of manganese ore on an abandoned iron mine property near Sugar Grove, in southwest Virginia. Shipments of manganiferous iron ore are being made to a Pulaski, Va., furnace, and plans are being formulated for extensive operation. Richmond interests are investigating old mines near Warminster, in Nelson County. This property was at one time extensively operated by English companies, but was abandoned about 30 years ago.

In the latter part of the year the Pittsburgh Manganese Ore Co. was organized by capitalists of that city. A tract of 140 acres of manganese property was acquired near Elkton, Va., and another of 150 acres leased. Lately about 100 tons of ore per week have been moved, most of it being shipped to the Carnegie Steel Co., at Pittsburgh. Some ore was also disposed of to various steel plants and to paint and brick manufacturers. The ore runs 46 to 50 per cent. Mn, and requires washing. The advisability of grinding is being considered, in which case larger sales will be made to paint and brick makers.[2]

Interest in manganese was keen on the Cuyuna range in Minnesota, due to advances in price as a result of the war. The Cuyuna-Mille Lacs property of the American Manganese Manufacturing Co. was the only important producer, and 150 tons per day was being hoisted from the shaft in the latter part of the year and arrangements were being made to greatly increase production. The ore runs from 8 to 23 per cent. Mn, and no considerable tonnage of 40 per cent. ore is claimed for the property.[3] The Duluth-Brainerd Iron Co. reports an ore analyzing 44.74 Mn, 0.089 P, and 3.97 SiO_2, but for the total width of ore encountered the average manganese is only about 20 per cent. Work is still in the development stage. Another property is that of the Iron Mountain Mining Co., 1½ miles from the Cuyuna-Mille Lacs.

The general supposition of fabulous wealth in the manganese ores of the Cuyuna range was found to be fictitious by the Minnesota Tax Commission. No commercial quantities of 40 per cent. manganese ore were found, and most of the so-called manganese ores were of too high iron or too low manganese for ferro or spiegel. Or, if the manganese was fairly high, the phosphorus and silica were also too high. Much of the

[1] *Eng. Min. Jour.*, Aug. 22, 1914.
[2] *Iron Age*, Oct. 8, 1914.
[3] *Eng. Min. Jour.*, Aug. 22, 1914.

manganiferous ore was found to be so low in iron that it has little, if any, market value.[1]

A manganese deposit is reported in South Carolina, at McCormick. It was originally a gold property. The manganese vein is 8 to 25 ft. wide and has been located for ¾ mile. Rich ore is found in the center of a vein 4 ft. wide, with leaner ore outside which would need crushing and jigging. Last summer 18 cars were shipped by the Eureka Manganese Co. But little work has been done, and the prospect deserves exploration. Outcrops of manganese ore are also reported in Georgia, but have not as yet been explored.[2]

California has been a producer of manganese ore for nearly 50 years; never in great quantity, and in lean years with no output whatever. Most of the yearly output went to chlorination plants, but the substitution of cyanide and other extraction processes has destroyed this outlet. In recent years the output has gone to local steel works and for the manufacture of dry cells. To date the entire production has been about 13,000 tons.[3]

The Ladd manganese mine in Alameda County, Cal., was sold recently to the Western Manganese Co. This mine has not shipped since 1902, but was previously the largest producer. The average exposure of the fault fissure is 4 or 5 ft. in thickness, and analyzes Mn 48.28 per cent. (MnO_2 62.10, MnO 18.00), SiO_2 8.70 per cent., S and P in traces. The above company has also contracted for the entire output of the adjoining Winship-Doak mine, and will refine the ores by mechanical and chemical treatment. The finished product will be sold for the higher class of trade for use in dry cells and the arts.[4]

Production of special alloy steel rails in 1914 was 4616 tons, against 11,864 tons in 1913, and 7494 tons in 1912. In these totals are included rails with nickel and copper additions, as well as manganese; but the tonnage of the former is small, and the totals may be taken as fairly representative of the output of manganese steel rails.

The world's production of manganese ores, so far as data are available, is as follows:

FOREIGN COUNTRIES

Russia.—Exports of manganese ore for 1914 were 737,300 tons, against 1,171,000 tons in 1913; a decrease of 433,700 tons, or 37 per cent. Exports were 989,000 tons in 1912, and 671,000 in 1911. Shipments practically ceased in the last quarter of the year, as is indicated by the reported export of 737,149 tons for the first 9 months. At the begin-

[1] *Iron Tr. Rev.*, Nov. 26, 1914.
[2] *Eng. Min. Jour.*, Dec. 26, 1914.
[3] *Min. Press*, Jan. 30, 1915.
[4] *Min. Press*, Feb. 13, 1915.

ning of the war, most of the railroad cars were commandeered by the government, and an embargo was placed upon manganese shipments. This was lifted in September. Later, the entrance of Turkey into the struggle closed the Dardenelles.

WORLD'S PRODUCTION OF MANGANESE ORE (*a*)
(In metric tons)

Year.	Austria-Hungary.	Belgium.	Bosnia (*b*)	Brazil (*d*)	Canada.	Chile (*d*)	Colombia.	Cuba.	France.	Germany.	Greece.	India.
1901	12,077	8,510	6,346	100,414	447	18,480	95	25,586	22,304	56,691	14,166	122,831
1902	12,883	14,440	5,760	157,295	175	12,990	*Nil.*	40,048	12,536	49,812	14,960	160,311
1903	11,489	6,100	4,537	161,926	135	17,110	(*c*)	21,070	1,583	47,994	9,340	174,563
1904	15,460	485	1,114	208,260	123	2,324	(*c*)	33,152	11,254	52,886	8,549	152,601
1905	23,732	*Nil.*	4,129	224,377	22	1,323	(*c*)	(*d*) 8,096	6,751	51,463	8,171	250,788
1906	20,577	120	7,651	121,331	84	35	(*c*)	(*d*) 13,997	11,189	52,485	(*d*) 9,200	579,231
1907	24,954	2,100	7,000	236,778	1	(*c*)	(*c*)	30,486	18,200	74,683	10,000	916,770
1908	27,257	7,130	6,000	166,122	*Nil.*	1	(*c*)	1,492	15,865	67,692	10,750	685,135
1909	29,966	6,270	5,000	240,774	*Nil.*	(*c*)	(*c*)	2,976	9,378	77,177	5,374	652,958
1910	28,964	*Nil.*	4,000	253,953	*Nil.*	(*c*)	(*c*)	(*c*)	7,925	80,559	41	813,761
1911	15,954	*Nil.*	3,600	213,000	5	(*c*)	(*c*)	.....	6,036	87,297	733	670,290
1912	12,471	*Nil.*	4,650	154,870	68	(*c*)	(*c*)	.....	5,576	92,474	7,719	637,444
1913	16,540	*Nil.*	4,700	81,200	*Nil.*	(*c*)	(*c*)	(*c*)	7,732	330,797	556	637,391
1914	.....	.....	.....	.....	25	.....	.....	.....	.....	.....	.....	730,016

Year.	Italy.	Japan.	New Zealand.	Portugal.	Queensland.	Russia.	Spain.	Sweden.	United Kingdom	United States. (*e*)
1901..	2,181	16,270	208	904	221	522,395	60,325	2,271	1,673	649,016
1902..	2,477	10,844	*Nil.*	(*c*)	4,674	536,519	46,069	2,850	1,299	989,519
1903..	1,930	5,616	71	30	1,341	414,334	26,194	2,244	831	671,151
1904..	2,836	4,324	199	(*c*)	843	430,090	18,732	2,297	8,880	461,854
1905..	5,384	14,017	55	(*c*)	1,541	508,635	26,020	1,992	14,582	877,482
1906..	3,060	54,339	16	22	1,131	1,015,686	62,822	2,680	23,126	1,141,681
1907..	3,654	20,589	26	1,374	1,134	995,282	41,504	4,334	16,356	517,177
1908..	2,750	11,130	*Nil.*	.....	1,403	362,303	16,945	4,616	6,409	633,650
1909..	4,700	8,708	6	.....	613	574,938	7,827	5,212	2,812	986,477
1910..	4,200	11,120	5	.....	805	(*d*)668,050	8,607	5,752	5,554	784,464
1911..	3,515	9,787	1	6	1,000	(*d*)584,000	5,607	5,377	5,067	644,288
1912 .	2,641	12,060	.....	6	313	(*d*)766,000	19,936	5,101	4,237	990,000
1913..	1,622	2,313	(*c*)	.....	27	1,171,000	21,594	4,001	5,480	791,407
1914..	.....	.....	.....	.....	6	737,300	.....	.....	.....	448,462

(*a*) Official statistics. (*b*) Includes Herzegovina. (*c*) Statistics not available. (*d*) Exports. (*e*) Includes manganiferous iron ore. (*f*) Six months.

Output of the Chiatouri[1] region has been almost entirely taken by foreign countries, with Germany as the important consumer. For the years 1911 to 1913, the approximate distribution was as follows, in metric tons.

During 1914 the new export tax upon manganese ore went into effect; a change from ¾ ct. to 1¼ per pood (36.11 lb). Coupled with this is the effect of the strike of 1913 in raising the cost of production of Chiatouri by ¾ ct. per pood. These increases were expected to give India another opportunity of improving her relative position in the manganese trade during the year, especially in times of inactivity in steel making, when the demand for manganese is below normal production.

[1] *Echo des Mines et Metal*, 1914.

DISTRIBUTION OF CHIATOURI ORES

	1911.	1912.	1913.
Germany	295,000	322,500	412,000
Austria	40,600	40,000	25,400
Belgium	66,100	193,500	182,500
France	42,000	42,200	55,100
Great Britain	125,900	202,000	246,500
Italy	3,900	.....	7,400
United States	16,100	96,300	137,700
Foreign	589,600	896,500	1,066,600
Russia	24,100	17,000	10,000

An important district is that in South Russia, especially for the supply of domestic demand and for overland shipment to Austria and Germany. The Nicopol mines on the Dnieper River are the important ones. The output in 1913 was about 20 per cent. of that of the Caucasus field. The ore is interstratified with wet clay, and the deposits are nearly horizontal, are from a few inches to 11 ft. thick, and rest on a bed of granite. The ore lies from 30 to 200 ft. from the surface. It requires crushing and washing, the resulting product being as rich as that of the Caucasus, but not so lumpy. Difficulties with mining labor is a deterrent to development.[1]

Much interest has been shown in the Podolia manganese region by German, and to a less extent, by British steel interests. These deposits are in southwestern Russia, and advantageously situated for shipment to Polish, German, and Austrian works. There are numerous mines in the district, which covers an area of 30 sq. miles. The deposits resemble those of Chiatouri, and occur in regular strata. The ore is pyrolusite, containing up to 60 per cent. Mn, 5 to 7 per cent. SiO_2, and traces of phosphorus. The reserves of ore deposits are very rich, and all conditions for mining and transportation are favorable. The geographical location of the Podolia deposits permits of exportation via Odessa to Great Britain for £6 per ton, as against the £9 10s. from Chiatouri. Some shipment of ore has been made to South Russian works, and development work is in progress.[2]

India.—Exports of manganese ore from India for the year 1914 were 537,960 tons; for the fiscal year ended March 31 the exports, together with destination, are given in the following table:

There was a decided falling off in the past year, amounting to 277,459 tons, or 38 per cent. For the past several years exports for the fiscal years as above have been: 1914, 718,000 tons; 1913, 708,000; 1912, 536,000; 1911, 573,000; 1910, 500,000 tons. Declared export values for recent years have been from $5.22 to $5.47 per ton.

[1] *Iron & Coal Tr. Rev.*, Feb. 19, 1915.
[2] *Min. Jour.*, May 23, 1914.

Year ended Mar. 31	1914, Tons.	1915, Tons.
United Kingdom	258,776	227,281
Germany	18,950	14,250
Holland	8,200	.....
Belgium	187,821	66,043
France	103,847	46,326
Italy	7,800	.....
Austria	10,310	4,030
Japan	16,018	9,157
United States	106,377	73,503
Total	718,049	440,590

Great difficulties were experienced, on account of the European war, n shipping ore from Bombay. Ocean freight advanced from 17s. 0.5d. to 24 and 25s.

According to the findings of the Geological Survey, manganese ninerals easily exploitable and of high manganese content, such as pyro-usite, will not be exhausted for from 25 to 50 years. In addition, there s a large reserve of mineral with 30 to 40 per cent. of manganese. Of the verage annual production of 650,000 tons in later years, 60 per cent. has ome from the central provinces, principally from Balaghat, Bhandara, nd Nagpour; about 18 per cent. has been from the province of Madras.[1]

Exploitation of Indian deposits is facilitated by the low wages and avorable conditions for working. On the contrary, transportation is ifficult. The greater proportion of the manganese mines is at a great istance from the coast, and part of the haul is by team. As a partial ompensation, the government has granted reduced railroad tariffs. The principal ports of shipment are Bombay, Calcutta, and Madras. The chief operating companies are the Nagpour Manganese Mining Syndi-ate, Central India Mining Co., Indian Mineral Mining Syndicate, and he Tata Iron & Steel Co.[2]

Brazil.—Because of the European manganese situation, interest in he Brazilian deposits has been very keen. The deposits of economic mportance are in the state of Minas Geraes, and development has suf-ered, in common with that of the iron ores, because of lack of shipping acilities and the difficulty and high cost of transport to the coast.

Ore of 45 per cent. average manganese, 0.016 phosphorus, 3 to 4 er cent. silica, and 3 to 6 per cent. iron, exists in the state of Bahia, ut no shipments have been made in recent years on account of unprofit-ble competition with the usual supplies. Mattogrosso deposits are also oo inaccessible to compete.

Exports of manganese ore from Brazil are reported as 81,200 gross ons in 1913, 154,870 in 1912, 173,941 in 1911, and 253,953 in 1910. Rio

[1] *Echo des Mines et Metal*, 1914.
[2] *Min. Jour.*, Jan. 23, 1915.

de Janeiro was the port of shipment for all of the ore since 1910. In 1913, exports to the United States were about 59,400 tons, to the United Kingdom 16,800 tons, and to Germany 5000 tons.

Average prices for the last few years have been 14 cts. per unit of manganese (f.o.b. Rio de Janeiro), less moisture, or about $6.70 per ton. Freight averaged about $3.50.

Other Countries.—Ores of manganese have been mined in Canada for many years, to a limited extent, and interest in what was formerly an important branch of Canadian mining will probably be stimulated by scarcity of Asiatic and European material. Nova Scotia and New Brunswick ores are of high manganese and low phosphorous content. In the former district a sorting and washing plant is installed at New Ross, and two well-defined leads are worked, the ore being largely pyrolusite with some manganite and psilomelane. Another important unworked deposit exists in Hauts County. In New Brunswick important deposits are found at Markhamville and Jordan Mountain. Ore from the latter yielded Mn 54.57, SiO_2 2.86, Fe, S, and P low. A large deposit of bog ore at Hillsborough has been worked to a limited extent, and manganese ore in considerable amount is known on Amherst Island.[1]

A large deposit of manganese ore—carbonate and oxide—is reported in southwestern Newfoundland, near the Belle Isle iron mines. At least 15,000 tons is in sight on the surface. The ore runs 40 to 50 per cent. in manganese, with silica 10 per cent. or less, and phosphorus very low.

Imports of manganese ore into Great Britain in 1914 were 479,435 tons, against 601,177 in 1913, a decrease of 20 per cent. For the first 8 months of 1914 imports were 356,330 tons, against 406,419 tons for 1913. The falling off in receipts for the last 4 months of 1914 was 71,653 tons, compared with the same period of 1914. British exports of ferro-manganese were approximately 111,000 tons in 1914, compared with 178,000 tons in the year previous.[2]

Austria-Hungary produced 16,540 metric tons of manganese ore in 1913, 12,471 in 1912, and 15,954 in 1911.

France imported 153,449 metric tons of manganese ore and 4,970 tons of ferro-manganese in 1914, as compared with 258,929 and 14,394 tons in 1913.

German imports of manganese ore for the first half of 1914 are given as 391,878 metric tons, compared with 378,492 tons for the corresponding period of 1913.

Spain is reported to have exported 8985 metric tons of manganese ore in 1914, against 27,793 tons in 1913. Official production for 1913 is given as 21,594 tons.

[1] *Min. Jour.*, Jan. 23, 1915.
[2] *Iron Age*, Feb. 4, 1915.

At the close of the year Cuban operators holding deposits of manganese ore running about 40 per cent. in manganese have been receiving inquiries, and some new development of these ores is being carried forward in the Santiago district. These ores have not heretofore been able to enter into general competition with Indian and Caucasian supplies.

Technology

H. Thaler gives the results of an investigation on the operation of blast furnaces making spiegeleisen. Four tests were conducted, with manganese in the product from 6.02 to 20.32 per cent. Complete heat and material balances are given. A basic slag rich in lime is necessary, and the manganese loss increases with the slag volume. Fuel consumption was 912 to 1279 kg. per metric ton, increasing in accordance with the increases in manganese noted above.[1]

Reduction of manganese takes place indirectly as well as directly; high furnace and top temperatures and slow driving favor reduction; manganese loss by volatilization is low with low spiegel, but increases with the manganese content of the pig, and for 20 per cent. spiegel is about 7 to 8 per cent. There is a fairly constant loss of about 1 per cent. manganese in the flue dust.

H. A. Brassert[2] gives some particulars regarding blast-furnace practice when making spiegeleisen of ferro-manganese. For maximum manganese in product, and least loss of metal in the slag, very basic slags are necessary. Loss of manganese by volatilization is kept down by concentration of the fusion zone. For a furnace operating on 80 per cent. ferro-manganese, a daily average tonnage of 125 was made with 3896 lb. of coke and 288 lb. of raw coal as a heat absorber to reduce top temperatures. The blast temperature was 1470° F., top temperature 550°. Loss of manganese in slag 5.8 per cent.

Operating on 19 per cent. spiegeleisen, a daily tonnage of 272 was made, with 2858 lb. of coke. Blast temperature was 1167° F., and top temperature 607°. Manganese in slag 2.18 per cent.

The above records were made after the furnace had produced 644,815 tons of ordinary pig iron on the same lining.

W. S. Potter[3] publishes results of investigations on manganese steel, largely of a metallographic nature, with pyrometer and microscope. Conclusions are drawn as to the constitution of these steels, based upon the data obtained.

R. A. Hadfield and B. Hopkinson[4] describe the magnetic and me-

[1] *Stahl u. Eisen*, Sept. 10, 1914.
[2] *Am. Iron & Steel Inst.*, May, 1914.
[3] *Bull. Am. Inst. Min. Eng.*, Feb., 1914.
[4] *Jour. Iron & Steel Inst.*, I (1914); *Am. Inst. Min. Eng.*, Mar., 1914.

chanical properties of manganese steel of 12 per cent. Mn and 1.25 per cent. carbon. The peculiar changes in the hardness and brittleness of such steel on quenching and annealing, and their relation to the loss and gain of magnetism, are discussed. The paper was presented and discussed mainly as a contribution to the controversy regarding the allotropic theory and the hardening of steel.

Silico-manganese with proportions of silicon varying as desired from 17 to 50 per cent., and manganese from 73 to 40 per cent., has found considerable use in European steel works as a substitute for ferro-silicon and ferro-manganese. The carbon varies from 0.1 to 2 per cent., decreasing with increase of silicon. The material is made in Sweden from very pure ores, and sulphur and phosphorus are very low.

Manganese steel castings are finding increasing use in steel works for heavy rolling-mill equipment. Mill table gears, spindles, and coupling boxes of this material have shown a life of ten times that of plain steel. The product is also of advantage where toughness and resistance to abrasion are desired, as in bells and hoppers, and ore-handling bucket parts.[1]

Manganese bronze and its properties and utility are described in several papers. It is really a high zinc brass, with Cu 55 to 60, Zn 40 to 45, and Mn not over 0.3 per cent. The tensile strength of cast bars is upward of 70,000 lb. per sq. in., with an elongation of 20 per cent. in 2 in.[2]

G. W. Gray[3] gives the results of measurements of the electrical conductivity of the copper-nickel-manganese alloys. Increased resistance is the result of manganese additions to the copper-nickel series.

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[1] *Iron Tr. Rev.*, Jan. 7, 1915.
[2] *Met. Chem. Eng.*, Feb., July, 1914; *Iron Age*, Sept. 3, 1914.
[3] *Bull. Rens. Polytech. Inst.*, 1914.

MICA

By J. Volney Lewis

Occurrence and Uses

Varieties.—The two commercial varieties of mica are *muscovite*, the potash or "white" mica, and *phlogopite*, the magnesia or "amber" mica. The latter, being a little softer, is preferred for some electrical purposes, particularly as insulation between commutator bars; but the great bulk of the mica of commerce is muscovite.

Sources.—The world's supply of mica is drawn chiefly from India, the United States, and Canada, in the order named, with smaller amounts from German Southwest Africa, Ceylon, Brazil, Mexico, and other countries. In the United States, deposits have been found in about 20 states, of which the important producers have been North Carolina, South Dakota, New Hampshire, Virginia, Colorado, New Mexico, Alabama, Georgia, and Idaho. For many years North Carolina has led, and during much of the time has furnished over half the total production of the country.

Modes of Occurrence.—White mica in commercial sizes and quantities occurs only in pegmatite, a coarse granitic rock consisting essentially of quartz and feldspar in very variable proportions and either with or without mica and other minerals. The feldspar may greatly exceed the quartz, or *vice versa;* in some places mica is altogether absent, while in others it forms half the rock or more. The masses of pegmatite vary in form from regular dike-like bodies to lenticular and exceedingly irregular masses, and in dimensions from a few inches to many feet or yards in thickness and from a few score feet to hundreds of yards in length.

Amber mica, which is obtained almost entirely from Canada, occurs with apatite and calcite, forming veins and irregular pockety deposits in dike-like bodies of green pyroxenite.

Colors and Defects.—In thin sheets muscovite is colorless or nearly so, and hence is called "white" mica, while phlogopite has a light yellowish-brown color known as "amber." In sheets $\frac{1}{16}$ in. or more in thickness, however, even muscovite shows well-defined shades of yellowish brown ("rum"), dark red ("ruby"), green, and dark gray. Some mica is speckled and stained with films of magnetite in the cleavage planes. Near the surface these may be partly changed to yellow and red (limonite and hematite), and "clay stains" may penetrate from the soil. These

imperfections render the mica unfit for glazing, but it is still good for electrical purposes. Granules of magnetite that penetrate the sheets are objectionable, however, in high potential appliances, since they weaken the insulating qualities. Mica that is much "ruled" or broken or has the "A," "wedge," or "herringbone" structure generally yields little that is large enough to cut into sheets, and hence is suitable only for grinding.

Uses.—Glazing, principally in stoves, which furnished the chief demand for mica in the early days, is now one of the minor uses. Only the best sheet mica is used for this purpose, and it commands a considerable advance in price over that used for electrical appliances, which is now the predominant use of mica. For electrical work much "micanite," or mica board, built up of small sheets of mica cemented together, is used instead of sheet mica. A little sheet mica is used in the manufacture of gas-lamp chimneys and the diaphragms of phonographs. Ground mica is used to give a silvery luster to wall paper; mixed with oil and grease it is used as a lubricant; mixed with shellac or other cementing materials it is used in the manufacture of electrical insulators of various forms, under the designation "moulded mica" and the more recent "micarta" and "bakelite micarta." When subjected to high temperature mica becomes soft, flexible, and opaque. This product, known as "annealed" mica or "Zilberglimmer," is prepared for use in commutators in competition with the Canadian "amber" mica.

Mining.—Mica mining is difficult and uncertain on account of the irregularities in shape and size of the containing pegmatite and similar irregularities in the quantity, quality, distribution, and sizes of the mica itself. There are no reliable indications to guide the miner in following the deposits, and a large amount of waste rock must be handled. Mica bodies within the rock are characteristically sporadic and pockety. Hence mica production is subject to great fluctuations, and many of the largest mines are operated more or less intermittently.

In many mica-producing regions fresh outcrops are continually being opened and worked in a small way, and these supply a large part of the mineral on the market. Also many of the dumps of old mines have been worked over, some of them a second time, for the smaller sizes of sheet mica and the scrap mica that had been thrown away during the earlier mining, and the yield from such operations has been large.

Statistics of Mica in the United States

The total value of mica produced in the United States during 1913, as reported to the U. S. Geological Survey, was $436,060. The average

domestic production of the 10 preceding years (1904–1913) was 1,376,861 lb. of sheet mica, valued at $257,068, and 2937 tons of scrap mica, valued at $40,464, or an average value of $297,532. These figures yield an average of 18.7 cts. per lb. for sheet mica and $13.78 a ton for scrap mica, for the 10-year period.

PRODUCTION OF MICA IN THE UNITED STATES, 1904–1914*

	Sheet Mica.		Scrap Mica.		Total Value.	Value of Imports.
	Pounds.	Value.	Short Tons.	Value.		
1904	668,358	$109,462	1,096	$10,854	$120,316	$263,714
1905	924,875	160,732	1,126	17,856	178,588	403,756
1906	1,423,100	252,248	1,489	22,742	274,990	1,042,608
1907	1,060,182	349,311	3,025	42,800	392,111	925,259
1908	972,964	234,021	2,417	33,904	267,925	266,058
1909	1,809,582	234,482	4,090	46,047	280,529	618,813
1910	2,476,190	283,832	4,065	53,265	337,097	725,823[1]
1911	1,887,201	310,257	3,512	45,550	355,804	505,552[1]
1912	845,483	282,823	3,226	49,073	331,896	755,584[1]
1913	1,700,677	353,517	5,322	82,543	436,060	947,780[2]
1914	.....	.....	.....	.....	.....	629,484[2]

* U. S. Geol. Surv.

IMPORTS OF MICA INTO THE UNITED STATES, 1905–1914[3]

	Unmanufactured.		Cut or Trimmed.		Ground.		Total.
	Pounds.	Value.	Pounds.	Value.	Pounds.	Value.	Value.
1905	1,506,382	$352,475	88,188	$51,281	.....	.....	$403,756
1906	2,984,719	983,981	82,019	57,627	.....	.....	1,042,608
1907	2,226,460	848,098	112,230	77,161	.....	.....	925,259
1908	497,332	224,456	51,041	41,602	.....	.....	266,058
1909	1,678,482	533,218	168,169	85,595	.....	.....	618,813
1910	1,424,618	460,694	536,905	263,831	.....	$1,298	725,823
1911	1,087,644	346,477	241,124	155,686	.....	3,389	505,552
1912	1,900,500	649,236	88,632	99,737	.....	6,611	755,584
1913	2,047,571	751,091	46,336[4]	191,924	290,757	4,765	947,780
1914	356,888	168,591	.....[5]	456,805	404,840	4,088	629,484

[1] Imports include value of ground mica, first reported in 1910.
[2] Statistics from the Department of Commerce.
[3] Statistics for 1905–1912, U. S. Geol. Surv.; for 1913 and 1914, Bureau of Foreign and Domestic Commerce, Department of Commerce.
[4] From Jan. 1 to Oct. 3.
[5] Quantity not reported for 1914.

In 1914 for the first time the value of cut and manufactured mica imported into the United States exceeded that of the unmanufactured, the former having increased in value from $191,924 in 1913 to $456,805 in 1914, an increase of 138 per cent., while the latter fell off from $751,091 to $168,591, a decrease of 77.7 per cent. There was also a decrease of 14 per cent. in the value of ground mica imported, in spite of an increase of 39 per cent. in the quantity. The net result was a decline in total value of imports from $947,780 in 1913 to $629,484 in 1914, a decrease of 33.6 per cent.

Mica is imported chiefly from British India and Canada, with smaller amounts from German Southwest Africa, Mexico, Brazil, and Japan.

EXPORTS OF MICA FROM THE UNITED STATES, 1910–1914[1]

	Unmanufactured.		Manufactured Value.	Total Value.
	Pounds.	Value.		
1910	.....	.....	.....	$20,543
1911	415,862	$15,649	$20,267	35,916
1912	356,601	14,936	25,876	40,812
1913	298,711	14,175	48,009	62,184
1914	433,329	25,962	39,140	65,102

Manufactured mica was exported chiefly to Canada, France, England, and Belgium; unmanufactured mostly to Germany, Belgium, England, and Canada.

Market Conditions.—The production of mica in British India and German Southwest Africa was greatly reduced after the beginning of the European war, and there was also a great falling off in foreign consumption. Dealers and importers report that during the first 8 months of the year the mica business was suffering from the general depression and there was rather an over-supply on hand. After the outbreak of the war the decrease in production was almost entirely offset by the corresponding decrease in consumption, and by the close of the year there was an upward tendency in prices.

In reviewing the position of the mica market, Messrs. Baker & Startin say:[2] "At the outbreak of war stocks in London were normal, and the subsequent temporary cessation of mining in India has enabled the market to absorb the arrivals without any very material alterations of rates. The war has naturally caused a decrease in the volume of business for the past year, as the Continental trade has practically ceased for the present. There are no new discoveries of importance to report, and, in view of the present limited market, the shipments from India are still considerably restricted."

Calcutta.—Values gradually declined during the first six months, and only moderate supplies have this year come forward. Present demand is somewhat weak, although rates are fairly steady. Best clear, however, is in constant request.

Madras.—Prices for some special sizes have been fairly well maintained, and a moderate, although irregular business, has been done throughout the year.

Splittings.—Extra fine qualities have been rather more sought after,

[1] Fiscal year ending June 30.
[2] *Min. Jour.*, Jan. 23, 1915.

hile medium to common qualities of both No. V and VI have been, nd are still, difficult of sale.

Amber.—Very little movement to record, with values unaltered.

The following figures are compiled from the returns of the London arehouses:

	Arrivals.	Deliveries.	Total Warehouse Stock Dec. 31, 1914.
ises (abt. 100 lb. each) 1914	22,718	24,405	17,718[1]
ises as compared with, 1913	40,174	30,115	19,405[1]
ises as compared with 1912	31,315	29,411	9,346[1]

There was also a great falling off in domestic production and, accord-g to an early estimate, the decrease in North Carolina for 1914 amounted) at least one-third. Twelve or 15 mines were worked more or less dur-g the year in this state, chiefly in Mitchell, Yancey, Jackson, and Macon ounties.[2]

Mica Mining in New Hampshire[3]

Mica deposits have been mined in Grafton, Cheshire, Sullivan, Merri-ack, Strafford, and Coos Counties. The principal mining districts are the towns of Rumney, Groton, Alexandria, Orange, and Grafton. The posits are in a broken mountainous country from 1000 to 3000 ft. ove sea level. Swamps, ponds, and lakes characteristic of the glaciated eas abound, much of the country is thickly covered with second growth mber and brush, and the roads off the main lines of travel are poor. [any of the farms have been abandoned and it is difficult for the miners) find boarding places or to buy food and forage for camps. The rocks e schists and gneisses with intruded granite and pegmatite.

During the last few years there has been a revival of mica mining in the ate and some of the mines have been worked on a large scale, but most them intermittently.

Mica Mining in Foreign Countries

Canada.[4]—Phlogopite, or "amber" mica, is produced almost exclu-vely in Canada. Deposits of white mica are known but are rarely ined. The two mining areas are located, one in Ontario and the other Quebec, and are separated by a belt of sedimentary deposits about 5 miles wide, in the neighborhood of Ottawa.

The value of mica produced in 1914 was $102,315, as compared with 194,304 in 1913, a decrease of 47 per cent. As shown by the following ble, the greater part of the output is exported to the United States.

[1] Including goods sold but uncleared.
[2] Dr. Joseph Hyde Pratt, State Geologist; letter to the writer.
[3] Summarized from Douglas B. Sterrett, *Bull.* 580-F, U. S. Geol. Surv., 1914, p. 69.
[4] Hugh R. de Schmid, *Min. Jour.*, June 13, 1914.

STATISTICS OF MICA IN CANADA, 1910–1914

	Production[1] Value.	Exports.[1]		Exports to U. S.[2]	
		Pounds.	Value.	Pounds.	Value.
1910	$190,385	937,263	$330,903	867,489	$333,196
1911	128,677	693,940	242,548	632,091	239,964
1912	143,796	895,338	334,054	724,849	213,750
1913	194,304	817,152	240,775	1,277,252	218,365
1914	102,315	669,163	178,940	679,215	167,256[3]

[1] Statistics of Production and Exports from Dept. of Mines, Canada.
[2] From U. S. Department of Commerce.
[3] Includes cut mica, splittings, and manufactures to the value of $42,471, the quantity of which is not reported.

Much of the mica is shipped to trimming shops in Ottawa, Hull, Kingston, and other places, where it is prepared for the market and its value considerably increased; hence the higher values of exports.

India.—This country produces white mica from the Hazaribagh district in the Province of Bengal and the Nellore district, Province of Madras. In the former the country is hilly, the pegmatite outcrops generally little altered, and all the good mica has been worked out near the surface. The primitive native methods have resulted in tortuous openings which in many cases have become difficult and dangerous to operate. The mica here is only "sickle-trimmed," that is, cut into irregular shapes by removing the rough edges and imperfections. The Nellore district, which furnishes about one-fourth of the product, is a low plain largely covered with recent alluvium, and rock outcrops are few. Steam pumps are more commonly used here and mining is done in a somewhat more modern and systematic manner, but primitive methods are still largely used. Much of the product is cut into rectangles, especially the better grades. "Ruby" mica is the chief product of Hazaribagh, while the best Nellore product is light green. The mica is trimmed more freely than in America and vast quantities of waste have accumulated, suitable for grinding, but entirely unused at the present time.

German East Africa.—A high-grade green to brown mica, equal in quality to that of India, is mined in the Uluguru Mountains and neighboring ranges. The rock is a variable biotite gneiss cut by pegmatite dikes that are nearly vertical and range from 30 to 70 ft. in thickness. The chief development has occurred in the last 10 years, and the output is much smaller than that of India. It is said to excel in splitting quality and, in the best grades, to yield smooth perfect sheets that are preferred for use as diaphragms in phonographs.

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MOLYBDENUM

By James Aston

No commercial production of molybdenum ores has been reported in the United States for the year. The Primos Chemical Co., however, which is a leading factor in the business, is developing a molybdenum mine near Georgetown, Colo. An old occurrence of mineralization was known at that place by a widespread yellowish stain of the rocks. This was lately found by representatives of the Primos Chemical Co. to be due to the molybdenum, and that company has acquired the property and will build a concentrating plant of 50 tons daily capacity. The reduction work will probably be done at the company's eastern plant.[1]

The above company reports that there has been an increased demand for molybdenum metal and ferro-molybdenum since the beginning of the present European war. Sales of the metal have been about 3 tons, and about 15 tons of ferro-molybdenum in 1914, all in the last half year. The electrical trade also bought some molybdic acid and ammonium molybdate.

The principal world's supply of molybdenum ores has continued to come from Australia, principally Queensland. The geology and treatment of these ores are described by L. C. Ball, Government Geologist.[2] During 1914 the demand was brisk in the earlier part of the year, but access to the principal markets was shut off by the war, so that production fell from 28.5 tons, valued at $58,000, for the second quarter, to 1.75 tons, valued at $4000, in the third quarter.

Australian production in 1913 is given as 145 tons, presumably concentrates of usual commercial grade of 80 per cent. MoS_2, or better. Of this, New South Wales is credited with 79 tons, and Queensland with 66 tons. The New South Wales deposits are in the Pambula division, where the Whipstich and Jingera mines are situated; also in the Glen Innes district and the Tenterfield and Deepwater divisions. Little work has been done in the last two fields. In Queensland the bulk of the ore has come from the Wolfram camp, with smaller lots from Bamford.[3]

A factor in the development of the deposits is the concentration of

[1] *Eng. Min. Jour.*, Jan. 9, 1915.
[2] *Queensland Govt. Min. Jour.*, Nov. 14, 1914.
[3] *Min. Jour.*, Apr. 10, 1915.

ow-grade ores, of which there is a plentiful supply, on the spot. Otherise transportation charges wipe out profits. Queensland already has lants, and a works for treating molybdenite ores is being established at ydney, N. S. W. It is expected that over 100 tons of concentrates will e despatched to England before the end of June, 1915, from New South Vales and Queensland.

The increased demand for molybdenum in the first half year is atributed to the discovery in France of a process for the preservation of ordite in hot climates, against its normally rapid deterioration. In onformity with the demand, the price of Australian ores rose in May to bout $28 per ton per unit of MoS_2, for ores of standard grade, that is, bove 85 per cent. sulphide and free from copper, arsenic, bismuth, and ungsten. This was about five times the price prevailing in the early art of 1913.

In this country, molybdenum sold for about $1.45 per lb. in the begining of 1914. Spot material rose to as high as $6 per lb. after the commencement of the war, due to sudden demand for war purposes. Prices ubsequently quieted down, but at the close of the year are in an unettled condition, since any sudden request for considerable metal for mmediate shipment will upset the market. Generally speaking, the emand for molybdenum appears to be increasing year by year.

Norway is an important producer of molybdenum ores. The deosits range from 1 to 3 per cent. of MoS_2, and there are a great number f claims and prospects. The ones of importance, however, are almost ntirely along the south and southwest coast, in a triangular belt. This elt contains the districts where ore has been found in anything like aying quantities. The general failure of the greater proportion of the rospects results from the disposition of the mineral in joints or following mall quartz stringers, making handling unprofitable. However, with ontinuance of high prices there should be increased activity in the workngs and in development. The Fjotland district, in the belt mentioned bove, is probably the richest in molybdenite of any yet found in Norway.

Lumping all of the molybdenite deposits of the world together, 1 per ent. MoS_2 would be high-grade ore, Norway included. One-half per ent. ore is profitable, providing quantity in bulky or massive form is here for easy blasting and mining.[1]

Canada has deposits of molybdenite which should become of great importance, and they are the subject of investigation, but production has not reached a commercial basis, and no output is listed in the mineral statistics. While good ore has been found in British Columbia, Nova Scotia and New Brunswick, the principal bodies occur in Ontario and

[1] *Min. Jour.*, Mar. 28, 1914.

Quebec. These deposits are usually free from deleterious impurities. The grade of run-of-mine will vary from 1½ to 6 per cent. of MoS_2. Certain of the British Columbia prospects are said to contain 10 per cent. MoS_2 for run-of-mine. All of the Canadian deposits may be considered concentration propositions, combined with a variable amount of shipping-grade ore, recoverable by hand sorting. Water concentration combined with the Elmore vacuum oil, or the Huff electrostatic processes, makes recovery of a clear mineral a fairly simple matter.[1]

In contemplating possible development of molybdenite deposits, consideration must be given to the fact that a high market could perhaps not be sustained in the face of any marked increase of production. Such development should be based on the possibility of having to carry on operations in the face of lower prices for molybdenite than now prevail.

The difficulty of commercial utilization of molybdenum ores is found in the separation of the metal from the gangue. While the molybdenite is very heavy, it is also soft and flaky, and a large proportion becomes powdered in the course of crushing, and is not recoverable by the ordinary methods of washing. The Elmore process has been satisfactorily adapted to the concentration of molybdenum ores, and is being successfully worked, among others, at two mines in Norway. Test runs on upward of 100 tons of material have shown an average betterment of grade of 84.8 per cent. of MoS_2 in the concentrates, with a percentage of extraction of 91.7. The ores were crushed to 30 mesh.

In principle, the process is based primarily upon the fact that, in a floating pulp of crushed ore and water, oil has a selective action for the molybdenite particles as distinct from the gangue. This selective action is materially increased in some cases by the presence of an acid. And secondly, upon the fact that the air or gases dissolved in the water are liberated, partly or entirely, upon subjecting the mass to a pressure less than that of the surrounding atmosphere. These liberated gases attach themselves to the greased mineral particles, and exert a buoyant effect which causes them, even though relatively heavy, to float to the surface of the liquid.

J. N. Friend and C. W. Marshall have studied the effect of molybdenum upon the corrodibility of steel.[2] Up to 4 per cent., this element does not appear to have much influence in tap water, salt, and acid tests. But for alternate wetting and drying, molybdenum acclerates corrosion, and appears to be undesirable if present in amounts above 1 per cent.

A patent has been granted to F. D. S. Robertson, of Toronto, Canada, for treating ores of molybdenum for the production of molybdic trioxide,

[1] *Min. Jour.*, Jan. 16, 1915.
[2] *Jour. Iron & Steel Inst.*, I (1914).

by roasting at 800° C. in the presence of excess oxygen. The volatilized product is collected in bags.[1]

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MONAZITE[1]

By Joseph Hyde Pratt

Sources of Supply of Thoria

Monazite was formerly considered a rare mineral without particular economic interest, but about 1886 the demand for thoria to be used in the manufacture of mantles for incandescent lamps led to the exploitation of monazite as a source of supply. As a consequence commercial deposits were found, and many localities were discovered where the mineral occurred in small quantities, or as an accessory ingredient of rocks.

Monazite is essentially an anhydrous phosphate of cerium, lanthanum and didymium, (Ce, La, Di)PO_4, accompanied by a small percentage of thoria, ThO_2, and silicic acid, SiO_2, which are very probably united as thorium silicate, $ThSiO_4$. Some monazites contain but a fraction of 1 per cent. of thoria, and one from Cleveland County, N. C.,[2] has been analyzed that showed none; others have been recorded that showed the presence of 18 to 32 per cent., but the majority contain from 3 to 9 per cent. of this oxide. It is the presence of the thorium oxide that

Locality.	Specific Gravity.	P_2O_5	Ce_2O_3	La_2O_3, Di_2O_3	$(Y, Er)_2O_3$	SiO_2	ThO_2
Amelia County, Va. (*b*)	.....	24.04	16.30	34.70	1.10	2.70	18.60
Amelia County, Va. (*b*)	5.30	26.12	29.89	26.66	.....	2.85	14.23
Portland, Conn. (*b*)	5.22	28.18	33.54	28.33	.....	1.67	8.25
Burke County, N. C. (*b*)	5.10	29.28	31.38	30.88	.....	1.40	6.49
Alexander County, N. C. (*c*)	5.20	29.32	37.26	31.60	.....	0.32	1.48
Madison County, N. C.	.....	.....	.....	.....	.....	.....	5.0
Ottawa County, Quebec, Canada, Espirito.	.....	26.86	24.80	26.41	4.76	0.91	12.60
Santo, Brazil (*e*)	.....	28.50	62.12		0.80	0.75	6.06
Alcobaca, Bahia, Brazil (*f*)	.....	28.46	61.40		0.70	0.64	6.50
Emmaville, New South Wales, Australia (*g*).	.....	25.09	36.64	30.21	.....	3.21	1.23
Southern Norway (*h*)	.....	28.27	28.06	29.60	1.82	1.65	9.34
Nirella Ganga, Ceylon (*i*)	.....	27.67	26.71	30.06	1.46	2.47	10.75
Pahang, Malay States (*j*)	.....	23.92	25.46	32.72	2.80	0.92	8.38
Puchong Babi River, Kenring Perak, Malay States (*k*).	.....	26.58	33.74	32.53	0.91	1.45	3.40

(*b*) Analyst, S. L. Penfield, *Amer. Jour. Sci.*, **24**, 250 (1882). (*c*) Analyst, Penfield and Sperry, *Amer. Jour. Sci.*, **26**, 322 (1888). (*d*) F. A. Genth, *Amer. Jour. Sci.*, **38**, 203 (1889). (*e*) S. J. Johnstone, Analyst. (*f*) S. J. Johnstone, Analyst. (*g*) C. Watt, *Min. Res. New South Wales*, p. 86, 1910 (*h*) C. W. Blomstrand, Geol. *Föreningens Förhandt*, **9**, 160 (1887). (*i*), (*j*), (*k*) S. J. Johnstone, *Jour. Soc. Chem. Ind.*, Jan. 31, 1914.

[1] Pratt and Sterrett, Monazite and Monazite Mining in the Carolinas, *Trans. Am. Inst. Min. Eng.*, 40, 313–340 (1910); Pratt, U. S. Geol. Survey., *Min. Res.*, 1901 to 1905; Sterrett, *ibid.*, 1906–1912; Nitze, N. C. Geol. Survey, *Bull. No.* 9, 1895.

[2] Reported to the author by Mr. Wm. E. Hidden of Newark, N. J.

gives the monazite its commercial value. The analysis occasionally shows also the presence of other constituents, as the yttrium and erbium oxides, zirconia, alumina, magnesia, lime and the oxides of iron, manganese, and titanium.

The preceding analyses of the mineral monazite will give a good idea of its chemical composition:

The monazite sand as it is concentrated from the alluvial deposits is a mixture of monazite, zircon, magnetite, ilmenite and garnet. A good many of these samples of sand, containing approximately 50 to 60 per cent. of monazite and in the condition that they are sold to the concentrating mills, have been analyzed for their thoria content, with the following results:

PERCENTAGE OF THORIA (ThO_2) IN NORTH CAROLINA MONAZITE SANDS

Locality.	ThO_2, Per Cent.
1. White Bank Gold Mine, Burke Co.	2.15
2. Hall Creek, Burke County	2.15
3. Linebacker Place, Silver Creek, Burke County	6.54
4. Long Branch, McDowell County	1.27
5. Alexander Branch, McDowell County	6.30
6. MacLewrath Branch, McDowell County	2.48
7. Proctor Farm, near Bellwood, Cleveland County	5.87
8. Wade McCurd Farm, Carpenter's Knob, Cleveland County	6.26
9. Davis Mine, near Mooresboro, Cleveland County	3.98
10. Henrietta, Rutherford County	1.93

In concentrating mills the monazite is almost completely separated from its impurities, so that the thoria content is raised approximately 30 per cent.

Samples of monazite sands from Big Hole River and Beaver Head County, Montana, which contained 65 per cent. of monazite, have been assayed by Dr. Chas. Palmer of the United States Geological Survey and found to contain 1.69 per cent. of thoria, which would be equivalent to about 2.6 per cent. in the pure monazite.

Other Minerals Containing Thoria

There are several other minerals that contain thoria, but it was not until 1905 that any of them were found in sufficient quantity to make them of interest commercially. Thorite and thorianite are now known to be in commercial quantity in Ceylon. Monazite, however, still continues to be the chief source of supply of thoria.

Thorianite.—An interesting mineral, thorianite, was discovered early in 1904 associated with corundum, zircon, tin, topaz, spinel, etc. The mineral was first found by Mr. W. D. Holland in the refuse from gem washing near Belangoda, Ceylon, and was supposed to be uraninite or

pitchblende, but upon analysis it was found to contain a very large percentage of thoria. The analysis of the mineral is as follows:[1]

ANALYSIS OF THORIANITE

Thorium oxide	76.22
Cerium, lanthanum, and didymium oxides	8.04
Zirconium oxide	Trace
Uranium oxide	12.32
Ferric oxide	0.35
Lead oxide	2.87
Silicia	0.12
	99.93

The thoria varies in the different analyses from 70 to nearly 80 per cent. No definite formula has been worked out for this mineral, and it is thought to be a mixture of the oxides of thorium and uranium. The thorianite occurs in cubical crystals, sometimes twinned, which have a jet black color. On worn surfaces the color is dull gray or brownish black. Its luster is resinous to sub-metallic, and it is brittle and breaks with an uneven to conchoidal fracture. In hardness it is 5.5 to 6.

The specific gravity of the mineral is given as 9.32, and it was observed in black, cubical crystals, which are fairly hard and give a brown streak. According to Mr. W. F. Petterd,[2] the powdered thorianite dissolves readily in dilute sulphuric as well as in nitric acid. It has also been shown to be highly radio-active because of its uranium content.

In August, 1905, the Ceylon variety was discovered in its matrix, which was a weathered pegmatite in which kaolin and hydrate mica were the chief constituents. A commercial test was made to determine the amount of thorianite in the rock, and it was found to contain 6 lb. of this mineral per ton of the rock as mined. Thorite has also been found associated with the thorianite in the pegmatite.

Thorianite was discovered in 1907 in black sand concentrates obtained from the vicinity of Norris, Montana.[3] These concentrates were examined by Mr. Wirt Tassin of the United States National Museum, who reported them to contain considerable magnetite, ilmenite with xenotime, zircon, garnet, quartz, ruby spinel (sparingly), monazite, and thorianite. The thorium content of these concentrates is very low. This is the first discovery of the thorium mineral, thorianite, in the United States.

Thorite.—Another mineral that contains a high percentage of thoria is thorite, an orthosilicate of thorium ($ThSiO_4$). The theoretical percentage of thoria in this mineral is 81.5, but usually it does not exceed 70 per cent. The pure orange-colored variety, containing the higher percentage of thoria, is known as orangite, and it has a specific gravity of 5.4 as compared with 4.5 for the ordinary thorite. The mineral crystal-

[1] Wyndham R. Dunstan, Ceylon Mineral Survey No. III; *Mining Engineering* (London), March, 1905, and *Min. Mag.*, May, 1905.
[2] *Min. World*, Sept. 16, 1905.
[3] U. S. Geol. Survey, *Min. Res.*, 1907, p. 791.

lizes in the tetragonal system, the crystals being similar to the simple zircon crystals consisting of prism and pyramid. In color the mineral varies from orange yellow and brownish yellow of the pure varieties to black inclining to brownish of ordinary thorite. It is sub-transparent to opaque with a vitreous to resinous luster, and varies in hardness from 4.5 to 5.

All the analyses of thorite show water and sometimes uranium. The thorium content in the analyses examined varies from 48.66 to 71.65, and the uranium content from 1.13 to 9.96. The water varies from 6.14 to 11.31.

This mineral has been found in commercial quantity in Ceylon,[1] has been mined to some extent, and a part of the production exported.

It has been found sparingly in the United States at one locality in New York State,[2] and in the granite of the Trotter mine,[3] Franklin Furnace, New Jersey. The general occurrence of this mineral seems to be in pegmatite or granitic rocks. There is one mineral which occurs in the United States in some quantity that approaches the thorite in composition and crystallization, and that is the mineral auerlite that is found associated with the zircon at the Freeman Mine, Henderson County, North Carolina, and which is described above.

There are several other minerals that contain thoria, but only one or two of them contain a sufficiently high percentage to make them worthy of consideration as a possible commercial source of supply of this oxide.

Auerlite.—This mineral crystallizes in the tetragonal system, the crystals forming a square prism terminated with a pyramid, resembling zircon in habit and angles. In color it is dull yellowish white to orange red, and has a resinous luster. It is only 2.5 to 3 in hardness, and has a specific gravity of 4.42 to 4.77. The mineral is of especial interest on account of its high percentage of thoria, 70.13. The mineral was discovered at the Freeman Zircon Mine by W. E. Hidden and J. B. Mackintosh.[4] An analysis of the mineral gave the following: SiO_2, 7.62; P_2O_5, 7.46; ThO_2, 70.13; (H_2O, CO_2), 11.21; Fe_2O_3, 1.38; CaO, 0.49; MgO, 0.29; Al_2O_3, 1.10.

The mineral is more or less altered, so that it can not be definitely determined just what its composition may be. It is evidently a hydrous thorium silicate, with perhaps a small amount of thorium phosphate. The mineral is closely associated with zircon and xenotime, and there has been observed parallel intergrowths of auerlite with these minerals.

[1] U. S. Geol. Survey, *Min. Res.*, 1907, pp. 791–2.
[2] Dana, Mineralogy, 6th Edition, p. 489, 1892.
[3] *Trans. New York Acad. Sci.*, **13**, 76 (1893).
[4] *Amer. Jour. Sci.*, **36**, 461 (1888).

When heated before the blow-pipe auerlite becomes brown, but turns orange again on cooling.

While Mr. W. E. Hidden was working the Freeman zircon mine near Zirconia, Henderson County, North Carolina, he made a special effort to separate and save the auerlite from the zircon, and during the brief operations of this mine during 1912 he obtained 1 kg. of auerlite. Mr. Hidden hopes during the future development of this property to be able to produce sufficient auerlite to make it a commercial source of thoria. Thus far auerlite has only been found at the Henderson County zircon mine.

Tscheffknite.—This is a massive amorphous mineral, velvet black in color and with a vitreous luster. Its composition is uncertain, and it is believed that it is an alteration product. It might be related to keilhauite. It is a titano-silicate of calcium and ferrous iron, the yttria and cerium groups of metals. It was first found in the Ilmen Mountains in the Ural. It has been identified in the United States in only one State, Virginia,[1] where it was first found on Hat Creek, near Massey's Mills, Nelson County. A mass weighing 20 lb. was picked up here which on analysis was found to contain 2.29 per cent. thoria. It has also been found in Bedford County to the south, where it is reported to be in some quantity. Analysis of samples from this locality gave only 0.75 to 0.85 per cent. The Ural variety is reported as containing 20.91 per cent. thoria.

Pyrochlore.—The common occurrence of pyrochlore is in octahedral crystals, which break with a conchoidal fracture. The mineral is brittle with a hardness of 5.5 and a specific gravity of 4.32. It has a vitreous to resinous luster, and varies in color from a dark reddish to blackish brown. In composition it is chiefly a niobate of the cerium metals, calcium and sodium, and with titanium and fluorine. The thoria content varies from 4.96 to 7.55 per cent. This mineral has only been reported from one locality in the United States—from St. Peter's dump, Pike's Peak, Colorado, where it occurs with zircon in syenite.[2]

Fergusonite.—Thoria to the amount of 2 per cent. has been reported to have been found in fergusonite, associated with thorianite in Ceylon. Analyses of fergusonite from most of the American localities do not show any thoria, but the Llano, Texas, fergusonite contains from 0.83 to 3.38 per cent. of thoria.[3]

Kochelite.—It contains only 1.23 per cent. thoria, and is therefore of no interest as a commercial source of this oxide.

[1] *Amer. Chem. Jour.*, **10**, 38 (1888); *Amer. Jour. Sci.*, **42**, 36 (1891); Dana, Mineralogy, 6th Edition, p. 718 (1892).
[2] Dana, Mineralogy, 6th Edition, p. 727 (1892).
[3] *Amer. Jour. Sci.*, **38**, 482 (1889).

Zirkelite.—Analyses show this mineral to contain 7.31 per cent. of thoria. It has not thus far been found in the United States.

Uraninite.—This mineral usually occurs massive and botryoidal, but is occasionally in octahedral crystals. It has a sub-metallic to greasy or pitch-like luster, and is often known as pitchblende. In color it is from greenish to brownish to velvet black. It is 5.5 in hardness and, when pure, has a specific gravity of 9 to 9.7. This mineral alters rather readily to gummite, so that very often the uraninite is found enclosed by a coating of the orange-red gummite. In composition it is a uranate of uranyl, lead, with usually thorium and the metals of the lanthanum and yttrium groups. Nearly all analyses show the presence of thoria, which varies from 1.65 to 9.79 per cent.

Thorogummite.[1]—This mineral occurs massive, associated with zircon and fergusonite at the gadolinite locality in Llano, Texas. It has a dull yellowish-brown color, which changes upon ignition to a dull greenish hue. It has a hardness of 4 to 4.5 and a specific gravity of 4.43 to 4.45.

In composition the mineral is a hydrous uranate of thorium and silicon, with lead, cerium and yttrium silicate, containing 41.44 per cent. thoria.

Chlorothorite is the name given provisionally by W. E. Hidden to a tetragonal thorium silico-uranate, which is similar in composition to the thorogummite.

Yttrochrasite.—This is a yttrium-thorium-urantitanate.

Occurrence of Monazite

Monazite is found very widely distributed as an accessory constituent in varying proportions of many granites and their derived gneisses. Thus it has been found in the porphyritic, granulitic, and schistose gneisses of the Maritime Mountains of Brazil, extending for a distance of 300 miles through the provinces of Bahia, Minas-Geraes, Rio de Janeiro, and Sao Paulo;[2] and in the pegmatitic portions of the granitic mica gneisses and hornblende gneisses of the South Mountain region of North Carolina, covering an area of some 3500 sq. miles in McDowell, Burke, Caldwell, Rutherford, Cleveland, Polk, Catawba, Iredell, Alexander, Lincoln, and Gaston counties, and extending into Spartanburg, Laurens, Greenville, Pickens, Anderson, and Oconee counties, South Carolina.[3] Although occurring in but small quantity, it has been identified in the granites or gneisses of Maine, New Hampshire, Massachusetts, Rhode Island, Connecticut, New York, North Carolina, South Carolina, and Georgia. In

[1] *Amer. Jour. Sci.*, **38**, 480 (1889).
[2] *Amer. Jour. Sci.* (3), **37**, 109 (1889).
[3] N. C. Geol. Survey, *Bull. No.* 9, p. 27.

North Carolina there are a number of mica schists that carry monazite, as those near the Deake mica mine Mitchell County, and at Milholland's mill, Alexander County.

In Idaho[1] monazite occurs as an accessory mineral in the immense granite areas that embrace the whole upper drainage basin of Boise and Payette rivers in the eastern portion of the State. A similar occurrence in western Montana[2] is indicated by the discovery of monazite in the sands and gravels.

It has also been found in pegmatitic dikes, where it is apt to be in large crystals, the largest that have been found being in an occurrence of this type. In the pegmatitic dikes of southern Norway, which have been mined for feldspar, monazite has been found in crystals and masses of size sufficient to be readily picked out by the miners while sorting the feldspar. There has probably never been more than a ton per year shipped from this locality. In a pegmatitic dike near Mars Hill, Madison County, N. C., rough crystals of monazite have been found up to 1½ in. in length. Some of the masses weighed 60 lb.

New occurrences of monazite in the eruptive granites and their derived gneisses are constantly being recorded, usually in the muscovite or biotite, not in the amphibole, varieties.

The presence of monazite or zircon is a pretty good indication of eruptive rock; hence no matter how badly a rock may be altered, if these minerals occur in it, it may be considered to have been originally eruptive. The only occurrence recorded of monazite in a volcanic rock is a variety of this mineral that was found in a druse of a Sanidine bomb near Coblenz, Prussia.[3]

Production

The production of monazite in the United States has declined very rapidly during the past 5 years, and during the year 1914 there were no shipments of monazite recorded for any of the localities in the United States.

There has been a little activity in the Carolina monazite field and several hundred pounds of monazite were shipped as samples. The Idaho localities showed little or no activity.

There have been several inquiries from New York and Chicago parties regarding monazite localities and its production, and it is not improbable that the continuation of the European war may lead to a renewed demand for American monazite.

[1] U. S. Geol. Survey, 18*th Ann. Rept.*, Pt. 3, 1898, pp. 630–632; and *Bull. No.* 430, 1910.
[2] U. S. Geol. Survey, *Min. Res.*, p. 960, 1910.
[3] Erg, *Poggendorff Annalen*, 5, 413 (1871).

The following table shows the trend of the industry for the past few years:

MONAZITE PRODUCTION IN THE UNITED STATES

Year.	United States. (a)			North Carolina. (b)		
	Pounds.	Value.	Per Pound.	Pounds.	Value.	Per Pound.
1905	1,352,418	$163,908	$0.121	894,368	$107,324	$0.120
1906	846,175	152,312	0.180	697,275	125,510	0.180
1907	547,948	65,754	0.120	(c)456,863	54,824	0.120
1908	422,646	50,718	0.120	(c)310,196	37,224	0.120
1909	541,931	65,032	0.120	(c)391,068	46,928	0.120
1910	99,301	12,006	0.121	83,454	10,104	0.121
1911	3,561	427	0.120	400	48	0.120
1912	1,272	159	0.120	*Nil.*	.....	.....
1913	*Nil.*	.....	.....	*Nil.*	.....	.....
1914	*Nil.*	.....	.....	*Nil.*	.....	.....

(a) Statistics are those of the U. S. Geological Survey. (b) Statistics for N. C. from 1893 to 1902 are estimates; those from 1903 to 1906 are from "The Mineral Industry of North Carolina;" those for 1910 are furnished by Joseph Hyde Pratt, State Geologist. (c) Statistics for 1907, 1908, and 1909 were collected jointly by the U. S. Geological Survey and the N. C. Geological and Economic Survey.

A considerable amount of the monazite used in the trade is from the Brazilian deposits, and in commenting on these deposits the American Ambassador[1] says:

"Deposits of monazite sand large enough to be of commercial value are found in Brazil only on the foreshore at certain points on the coast of the State of Espirito Santo and a few miles north of the town of Prado in the State of Bahia. Since the foreshore belongs to the National Government, the Directoria da Patrimonia Nacional, the section of the Ministry of Finance that controls national property, is in charge of these deposits. Authorization to lease them, under such form of contract as the Minister of Finance may decide, is accorded to that minister by virtue of a provision that appears annually in the budget law of the Republic whenever such concessions fall in.

"There are at present two active concessions and one passive one. The first of these belongs to a French company, of which Mr. Luiz Rezende, of Rio De Janeiro, is the administrator; the second to Mr. John Gordon who, although an American citizen, divides his business interests between England and Brazil. The third, the awarding of which to a Brazilian company was published in the Official Gazette of September 1, 1912, was declared annulled in the issue of the same Gazette of November 4, 1914, because this company found it unprofitable to continue mining under the conditions imposed by the Government. Bids for the leasing of this concession may be opened, provided that the budget law for next year makes provision therefor.

"The French company has an exclusive contract with one concern and does not accept orders from other companies. Mr. Gordon, how-

[1] American Ambassador Edwin V. Morgan, Rio de Janeiro, Dec. 11, 1914, *Com. Rept.*, Feb. 3, 1915.

ever, is accepting general orders and may be addressed in care of Gordon & Rogers, 141 Broadway, New York City, as well as in care of Rio Lighterage Co., Rio de Janeiro. Prices have advanced considerably."

IMPORTS

The imports of thorium nitrate and of monazite sand are given in the table below:

IMPORTS OF THORIUM NITRATE AND MONAZITE (a)

	Year.	Pounds.	Value.	Per Pound.
Thorium nitrate entered for consumption.....	1910	108,597	$218,713	$2.01
	1911	121,111	238,841	1.97
	1912	117,485	225,386	1.92
	1913	112,105	212,263	1.89
	1914	101,927	239,376	2.35
Monazite sand (and thorite) entered for consumption.	1910	453,554	$39,699	$0.0875
	1911	705,149	60,542	0.086
	1912	556,959	47,334	0.085
	1913	1,145,010	94,425	0.082
	1914	770,842	61,595	0.080

(a) Bureau of Statistics of the Department of Commerce and Labor.

In addition to the above, about 2500 lb. of thorium acid and other thorium salts was imported in 1914.

NICKEL AND COBALT

By James Aston

Although the United States has been the all-important producer of ickel during 1914, it has remained a non-producer of ores, and has drawn ractically all of its supplies of raw materials from other countries. Imorts for 1914 are given as 35,006,770 lb. of nickel, chiefly in the form of re and matte, as against 47,194,101 lb. in 1913. Exports, largely as the ietal, were 27,595,152 and 29,173,088 lb. in the respective years.

Complete statistics for several years past are noted in the following ible:

ear.	Imports.							Exports.	
	Nickel Ore and Matte.		Nickel Alloys. (a)		Nickel Mnfrs.	Cobalt Oxide.		Nickel. (b)	
	Long Tons.	Value.	Pounds.	Value.	Value.	Pounds.	Value.	Pounds.	Value.
00.	25,670	$1,183,884	(c) 455,188	$139,786	.....	54,073	$88,651	5,869,906	$1,382,727
01.	52,111	1,637,166	635,697	209,956	$ 2,498	71,969	134,208	5,869,655	1,521,271
02.	14,817	1,156,372	752,630	251,149	30,128	79,984	151,115	3,228,607	925,579
03.	15,936	1,285,935	521,344	170,670	37,284	73,350	145,264	2,414,499	703,550
04.	8,548	915,470	589,555	203,071	2,950	42,352	86,925	7,519,206	2,130,933
05.	13,451	1,626,920	941,966	331,920	3,291	70,048	139,377	9,550,918	2,894,700
06.	15,156	1,816,631	210,000	77,373	8,963	41,084	83,167	10,620,410	3,493,643
07.	(d)16,888	2,153,873	180,025	80,994	9,159	48,013	74,849	8,772,578	2,845,663
08.	(e)16,322	2,396,217	241,868	91,388	10,010	219,098	17,077	9,770,248	3,297,988
09.	(f)18,578	2,927,975	277,911	104,019	4,279	12,132	11,096	12,048,737	4,101,976
10.	(g)28,519	4,085,076	323,239	125,013	14,759	6,124	4,806	15,244,937	4,704,085
11.	(h)23,993	3,918,556	293,301	104,160	.....	14,561	7,576	25,099,586	8,283,777
12.	(i)33,101	5,638,456	(j)223,168	103,300	17,203	31,848	15,132	25,815,016	8,515,332
13.	(k)37,623	6,427,639	336,590	133,917	37,200	47,277	26,154	29,173,088	9,686,794
14.	29,564	4,956,448	109,213	45,146	13,010	227,886	220,593	27,595,152	9,455,528

(a) Includes nickel oxide, and alloys of any kind in which nickel is the material of chief value, in igots, bars, and sheets. (b) Comprises domestic nickel, nickel oxide, and matte. (c) Not separately umerated; included in "Nickel Ore and Matte." (d) Contained 18,418,305 lb. nickel; not reported revious to 1907. (e) Contained 16,586,423 lb. nickel. (f) Contained 21,916,182 lb. nickel. (g) ontained 32,050,032 lb. nickel. (h) Contained 29,545,967 lb. nickel. (i) Contained 42,168,769 lb. ickel. (j) Weight of nickel alloys only, value $85,059. (k) Contained 47,194,101 lb. nickel.

Destination of exports of nickel from the United States in the past years has been as follows:

	1911, Lb.	1912, Lb.	1913, Lb.	1914, Lb.
rance	5,463,358	5,083,947	3,631,858	3,457,157
etherlands	9,101,150	7,387,447	6,622,811	855,168
nited Kingdom	7,196,259	8,191,364	8,221,640	10,836,369
thers	3,338,819	5,152,258	10,096,779	12,446,458
	25,099,586	25,815,016	29,173,088	27,595,152

Practically all of the domestic production can be credited to the International Nickel Co., manufacturing nickel at Constable Hook, N. J., from matte received from its smelter at Sudbury, Ontario. Another producer of metal is the United States Nickel Co., which refines matte from New Caledonian ores, and shipped from Europe to its plant at New Brunswick, N. J.

A considerable production of nickel, chiefly in the form of nickel salts, results as a by-product in the refining of copper ores mined in this country. This nickel is recovered by evaporating the electrolyte of copper refining plants, and the amount so recovered in 1913 is reported by the United States Geological Survey as equivalent to 481,565 lb. of nickel. It is stated that the blister copper produced at certain western smelteries contains from 11 to as high as 944 lb. of nickel in 100 tons of blister, depending upon the source of the ore.[1]

Nickel occurs at many places in this country. The old Gap mine in Lancaster County, Pennsylvania, was an important producer in its day, but has been closed for the past 20 years. The Mine LaMotte, in Missouri, has nickel present with the pyrite which is associated with its lead ore. Nickel ores occur in Douglas County, Oregon, and near Webster, North Carolina, but the deposits have not been profitably exploited, while there are deposits, not as promising as expectations, at Lovelock, Nevada. Recently a deposit was reported at San Diego, California, but apparently of insufficient tonnage to warrant profitable exploitation. In fact, while there is a steady and growing demand for nickel in the industries, the world's output seems to keep well in pace with the demand, and there appears to be an ample supply to meet present needs. So long as Canadian supplies and conditions for their import do not change materially, the need or chance of profitable exploitation of limited or lean deposits in this country seems rather remote. Should such contingency arise as has happened abroad as a result of the European war, availability and utility of domestic sources of supply would be put into a different category.

The report of the International Nickel Co. for the year ended March 31, 1915, shows a net profit of $5,598,071 after deducting all expenses, depreciation, exhaustion of mineral, and other charges. For the year previous, the figure was $4,792,664. During the year $595,976 was expended for additional property. Dividends of $534,756 were paid on preferred stock, and $4,753,937 on common. The balance sheet shows assets of $11,117,881 and liabilities of $2,770,073. The number of stockholders increased from 3752 to 4465 during the year.

The price of refined nickel in New York remained fairly constant

[1] *Min. Sci. Press*, Dec. 12, 1914.

throughout the year, quotations being from 40 to 45 cts. per lb. for shot, blocks, or plaquettes, depending upon quantity. Electrolytic nickel was quoted at 5 cts. per lb. higher.

Canada.—Canadian operations were much disturbed because of the European war. Comparative figures of production and export are given in the following table:[1]

CANADIAN PRODUCTION AND EXPORT
(From Preliminary Report, Mineral Production of Canada—1914)

	1911 Tons of 2000 lb.	1912 Tons of 2000 lb.	1913 Tons of 2000 lb.	1914. Tons of 2000 lb.
Ore mined	612,511	737,584	784,697	1,000,364
Ore smelted	610,834	725,065	823,403	947,053
Bessemer matte produced	32,607	41,925	47,150	46,396
Copper content of matte	8,966	11,116	12,938	14,448
Nickel content of matte	17,049	22,421	24,838	22,759
Spot value of matte	$4,945,592	$6,303,102	$7,076,945	$7,189,031

	Lb.	Lb.	Lb.	Lb.
Nickel contained in matte, etc.:				
Exported to Great Britain	5,023,393	5,072,867	5,164,512	10,291,979
Exported to United States	27,596,578	39,148,993	44,224,119	36,015,642
Exported to Other Countries	.....	.....	70,386	220,706
	32,619,971	44,221,860	49,459,017	46,538,327

The total production of matte in 1914 was 46,396 tons, valued by the producers at the smelters at $7,189,031, and containing 28,985,825 lb. of copper and 45,517,937 lb. of nickel. The tonnage of ore smelted (part being previously roasted) was 947,053. The production in 1913 was 47,150 tons of matte containing 25,875,546 lb. of copper and 49,676,772 lb. of nickel. In 1914 there was an increase in copper content and a falling off in nickel.

There is also a small recovery of nickel in the form of nickel oxide from the Cobalt district ores, the production in 1914 being reported as 391,312 lb. of oxide valued at $26,483.

At the outbreak of the war the Canadian Copper Co., the International Nickel Co.'s subsidiary in that country, closed down a considerable portion of the mining and smelting operations in the Sudbury district. Crane Hill mines Nos. 2 and 3 were closed, and at Creighton, the big producer, only one shift was worked. Production was cut from 40,000 tons per month to less than 30,000. Only two furnaces were operated at the smelting plant at Copper Cliff, instead of six, and the reverberatory

[1] *Canad. Dept. Mines*, Adv. Rept.

plant was closed. The company had big supplies on hand, and much matte in transit, and was in a strong position. Before the close of the year, operations were resumed on a larger scale, but the company's output for the year was greatly reduced. The International Nickel Co. had a large export trade with France, Germany, and Italy, as well as with England.

The Mond Nickel Co., with its refining plant in Great Britain and its principal market there, and with a greatly increased capacity because of enlargement of its smelting plant at Coniston, nearly doubled its output. Ores from the Alexo mine north of Cobalt were also reduced at this smelter.

The nickel-copper ore of the Sudbury district is reduced in smelters and converters to a Bessemer matte containing from 77 to 82 per cent. of the combined metals, and shipped in that form to Great Britain and the United States for refining. A portion of the matte produced by the Canadian Copper Co. is used for the direct production of Monel metal, an alloy of nickel and copper, without intermediate refining of either metal.

In the latter part of the year, Canada became very much agitated because of the assumption that England's enemies were receiving nickel which had been made from Canadian raw materials. The agitation was kept alive by the press, and there was much controversy over the question of legislation to prohibit exports of nickel other than that refined in Canada. Such a measure would affect primarily the International Nickel Co. The more conservative press contended that while such a move would no doubt eliminate one possible source of supply for Germany, it would be of almost equal seriousness to the allies of England, and to the latter as well, since much of their nickel supply is obtained from the United States. Furthermore, the International Nickel Co., instead of removing its plant from New Jersey to Canada, might develop its large holdings in New Caledonia, to the detriment of Canada and the districts dependent upon the nickel industry.

The Canadian authorities issued assurances that the exports of the International company were being carefully scrutinized by government agents. The company, through its president, denied the domination or influence of German interests. It contended that the present state of the art does not warrant refineries in Canada as an economic proposition, and that an embargo would prove detrimental to Canada's nickel industry. Fuel at Sudbury would cost double the price in New Jersey, and salt cake over double. The present large plant would have to be abandoned and its value charged to refining costs in the new one. And heavy sales of nickel in the United States would carry the additional

urden of 10 per cent. duty. One of the French companies thus finds it f advantage to make matte from ore in Holland, and then refine this t New Brunswick, N. J., to metallic nickel, in order to cope with the dvantage of the International Nickel Co. in home markets. It is pointed ut by government officials, also, that since 1907 there has been a onus of 6 cts. per lb. offered on all nickel refined in Ontario, with no akers.

Early in 1915 the agitation culminated in the appointment of a ommission to study the feasibility of nickel smelting and refining in anada, and the prohibition of export of nickel ores and matte.

Other Countries.—Exports of nickel ore from New Caledonia in 914 were 94,154 tons, an increase of 964 tons from 1913. Exports of ickel matte were 5287 tons in 1914, a decrease of 606 tons.

New Caledonia is the only serious competitor of the Sudbury district. Most of the ore has been exported and treated in France, Germany, and cotland in small smelters and refineries operated by the Societe le Nickel. The nickel occurs in veins of hydrated silicates in serpentinized nasses of peridotite, and is not associated with copper. The richest ilicates are soft green minerals known as garnierite and noumeaite. The veins are small and many of the deposits have been long since worked ut. A large number of small veins are being worked in various parts f the island, and the deposits are capable of yielding a much larger utput than at present. Owing to the nature of the deposits and their ocation, the New Caledonia ores do not yield as large a profit as the Sud- ury, although they are richer.[1]

The Evje Nickel Works, near Christiansand, Norway, which were emporarily shut down, have, with a new supply of war material, started gain on their former scale. The Norwegian works are steady pro- ucers, but small compared with the Canadian operations. Annual utput is about 400 tons of the metal. At the beginning of 1915, Norway laced an embargo upon the export of nickel ores and unwrought nickel, xcept that produced by Norwegian works.

In the first half of 1914, Germany imported 1066 metric tons of ickel and 13,042 tons of nickel ore. Comparative figures for the same eriod of 1913 were 1189 and 6643, tons, respectively. Exports for the rst half of 1914 were 1445 tons of nickel, compared with 1018 tons in he same period of 1913. The price of nickel in July, 1914, was $788 er ton, but rose to from $1333 to $1455 in November.

In England, the Mond Nickel Co. reported a very satisfactory ear, with increase of profits. A reorganization was contemplated to ake the nominal capital correspond more nearly with the assets. The

[1] *Canad. Min. Jour.*, Dec. 1, 1914.

Sudbury properties are more valuable than the book values. The intention is to abolish the deferred shares and have only cumulative and non-cumulative preferred and ordinary. The reorganized company will have 900,000 ordinary shares of par value of £1 each.

A. G. White describes the Tasmanian nickel deposits. They have been known for some time, but little has been done until recently in exploration and development. There are two principal deposits, and considerable development has been done on the Dundas deposit of high-grade nickel-copper ore. Two companies are operating successfully. The ore is sulphide, with 8 to 12 per cent. Ni and 4 to 6 Cu, but becomes lower-grade with depth. The operations are burdened with heavy transportation charges to Europe, which could be materially lessened by smelting to matte of 80 per cent. metal. The Trial Bay deposits have had little development or exploration. The formation resembles New Caledonia, and is of low grade, generally less than 1 per cent. metal, but amenable to water concentration.[1]

Technology

The Madagascar Minerals Syndicate proposes to extract the greater proportion of the nickel from their low-grade garnierite deposits by solution with sulphuric acid, rendering the nickel and magnesium soluble, and eliminating the silica. The nickel is to be precipitated as the hydrate by lime, and separated by solution in strong acid. The nickel salt, will be crystallized out and converted to the oxide by heating.[2]

K. Thomas discusses the application of magnetometric methods of survey to the Sudbury nickel deposits. The nickel minerals are almost invariably associated with magnetic sulphide of iron. Earlier work was disappointing, but with recognition of geologic features, the magnetic determinations form a useful aid in exploration work.[3]

B. Dudley[4] notes experiments to separate nickel and iron from copper in ores of that nature, and recover the nickel and iron as an alloy and the copper separately. The ore is roasted to low sulphur, enough sulphur is added as raw pyrrhotite or clean iron pyrite to re-sulphatize the copper and the mixture is chloridized with salt. The copper alone is soluble, and the iron and nickel are recovered as oxides and afterward smelted in a blast furnace to an alloy. The commercial feasibility has not been proved by the experiments, but the conditions of operation have been well worked out.

[1] *Min. Mag.*, Feb., 1915.
[2] *Echo des Mines et Metal.*, 1914.
[3] *Min. Sci. Press*, Mar. 21, 1914.
[4] *Am. Inst. Min. Eng.*, Dec., 1914.

V. Hybinette[1] has patented a process (U. S. 1098443) for treating ores with nickel, copper, and cobalt. Fine ore is partly roasted, and the copper and cobalt minerals removed by magnetic treatment. The magnetic concentrate of 12 to 20 Cu, 2 to 5 Co, and 2 to 5 Ni is smelted to matte, roasted to remove sulphur, and leached with sulphuric acid. The copper is dissolved, leaving nickel and cobalt in the residue, with little or no iron.

Patent was granted (U. S. 1101115) to W. Borchers and H. Pedersen for a process to treat copper-nickel ores. The ore is smelted with limestone to a matte in the electric furnace. This is treated with sulphuric acid, and the copper thrown out by precipitation with hydrogen sulphide, leaving the nickel as the soluble sulphate. After filtration, the separate metals are recovered by smelting.[2]

H. L. Sulman and H. F. K. Picard have taken out patent (U. S. 1091545) for the recovery of nickel from garnierite, by solution with sulphuric acid. Quantity of acid and temperature are controlled to avoid undue solution of magnesia. The soluble nickel salts are removed by filtration and precipitated with powdered magnesia.[3]

O. Dyckerhoff has been granted patent (U. S. 1085675) for a process permitting recovery of all of the silver and the greater part of the cobalt, nickel, and arsenic in ores of this character. By heating the ore with salt and clay there is formation of sodium silicate and chlorine, which latter forms silver chloride, in turn absorbed by the Al_2O_3 of the clay. Cobalt and nickel are in a form soluble in dilute acid, and the arsenic is recovered as sodium arsenate. Recovery of the metals is by precipitation and smelting. Repeated roasting and leaching may be needed for high extractions, and tests have shown yields of 98 per cent. of the silver, 67 per cent. of the nickel and cobalt, and 95 per cent. of the arsenic.

The Colvocoresses patents (U. S. 1106785 and 1106786) propose to treat basic ores of copper-nickel-iron by crushing and roasting to under 1 per cent. sulphur, and then smelting with suitable flux in the electric furnace to obtain a ferro alloy with 1.5 to 12 per cent. of copper and nickel.[4]

Experiments in direct nickel-copper sulphide ore smelting are contemplated in Ontario, Canada. The Mond Nickel Co. will use the Fink furnace at Coniston, and the Canadian Copper Co. the Knudson furnace at Copper Cliff. The plan is to blow to 40 per cent. matte, and then treat in a converter to make the 80 per cent. Cu-Ni product.[5]

G. H. Clamer has patented (U. S. 1086314) the use of Monel metal

[1] *Met. Chem. Eng.*, Aug., 1914.
[2] *Met. Chem. Eng.*, Oct., 1914.
[3] *Met. Chem. Eng.*, June, 1914.
[4] *Eng. Min. Jour.*, Sept. 5, 1914.
[5] *Eng. Min. Jour.*, July 11, 1914.

in producing iron-nickel-copper alloys; also the production of these directly from sulphide ores by roasting and reduction.[1]

D. H. Browne describes experiences with the coal-dust fired reverberatory furnaces at the Canadian Copper Co. Fuel ratios and practice, and furnace construction and operating details are discussed.[2]

P. Chevenard[3] reports investigations of a metallographic nature on the nickel steels, and discusses the nature of the reversible and irreversible transformations of these materials.

G. K. Burgess and P. D. Foote have determined the emissivity of nickel oxide in the temperature range 600–1300° C; also for solid and liquid cobalt and nickel metals.[4]

Cobalt

Ontario produced, in 1914, 97 tons of cobalt ore. It is stated that fully $10,000,000 has been lost since 1904 in the 7000 tons of cobalt in the residues of the silver ores of that province. Actually, $566,000 has been received for the cobalt made. About one-third of the cobalt output of the district has been put on the market as black cobalt oxide, and used as blue coloring. Two-thirds has not been utilized, and large amounts have been accumulated in smelter residues and slags.[5]

The investigations of H. T. Kalmus[6] upon cobalt have continued under the auspices of the Canadian government, and Part 2 of the published results has appeared. The determinations were largely upon the physical properties of the metal, some of which are as follows: density, 8.79 to 8.92; hardness, 124 Brinell; melting point, 1467° C.; tensile strength as cast, 34,400 lb. per sq. in., but very brittle; strength increased to 61,900 lb., and fair ductility, with 0.25 carbon; electrical resistance, 8.96 microhms per cu. cm. for pure metal; magnetic, up to 1100° C. Typical microsections are given.

New Caledonia exported 920 tons of cobalt ore and 25 tons of matte in 1914.

Patent has been granted to C. G. Fink (U. S. 1119588) for a process for reduction of rebellious ores, arsenious, sulphurous, etc. Powdered smaltite, for example, is mixed in proper proportions with powdered lime and calcium carbide, and heated *in vacuo* for 1 to 2 hr. at a temperature up to 1500° C. The interaction of lime and calcium carbide yields metallic calcium, which in turn reacts with the cobalt arsenide, forming calcium arsenide and metallic cobalt.

[1] *Met. Chem. Eng.*, June, 1914.
[2] *Am. Inst. Min. Eng.*, Feb., 1915.
[3] *Rev. de Metal*, Aug., 1914.
[4] *Bull.* 224, 242, Bureau of Standards.
[5] *Min. Sci.*, Feb., 1914.
[6] *Bull.* 309, Canad. Dept. Mines.

L. Goldmerstein claims that cobalt can be introduced into steel by adding it as the fluoride. The fluoride can be made cheaply, and a cobalt tool steel may be made at a price practically equal to that of ordinary high-speed steel.

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PETROLEUM AND NATURAL GAS

By David T. Day

The United States Geological Survey has determined the marketed and used production of petroleum in the United States for the year 1914 as 265,762,535 bbl., a gain of over 17 million barrels from the amount produced during the previous year.

Any statement of the number of barrels of crude petroleum produced is unsatisfactory, because of the fact that not more than one-fourth of this crude oil finds any utilization in the natural state. It is really the "ore" from which useful oils are produced. It differs from other ores, however, in the fact that practically all the components of crude petroleum are, after separation (refining), utilized, whereas with other ores some one particular substance is sought, and usually the remainder of the ore is valueless. With petroleum, however, the proportion of each useful product obtained varies with the kind of crude, and with the progress of the art of refining, so that the percentage of different products can not be calculated from the crude produced in 1 year nor compared with the amount produced in another. Inasmuch as the proportion of the most highly valued products from petroleum is increasing each year, the real value of the crude material advances proportionately and might give a clear measure of the total value of the products obtained were it not for the enormous fluctuations in the price of petroleum, due to variations in the supply. Thus the total value for the product of 1914, while greater in quantity and utilized to greater advantage, was nevertheless below the total value of the smaller product of 1913, or $237,121,388.

While referring to the advances in the utilization of petroleum, it may be pointed out that California is the only state where any considerable percentage of the crude oil product is used as such without refining (chiefly for fuel), and even in that state the proportion of the product burned as crude oil decreased from approximately 50 per cent. in 1912 to an estimated 25 per cent. in 1914. Of the 75 per cent. which went through some kind of refining process in California, a greatly increased proportion was used during last year for the production of high-grade products such as lubricating oils of superior quality, high-grade illuminating oils, and gasoline, while a still greater improvement from the practical point of view has been shown in the grade of asphalt pro-

duced for road, roofing, and binder purposes. At least 2,800,000 bbl. of the total California product appeared in this form in 1914. The improvement consisted in producing very much more ductile asphalt, which made road surfaces of greater wearing efficiency. These advances were made particularly evident by an examination of the exhibits at the Panama-Pacific Exposition by the International Jury of Awards, where these California products compared most favorably with the older and well-established products from the eastern states which have long been accepted as the highest standards of the world for lubricating and illuminating oils, gasolines, and various grades of asphalt, as well as for floor dressings and household cleaning fluids, etc.

Another great advance chronicled by the petroleum exhibits of the Panama-Pacific Exposition was the achievements in the conservation of petroleum and natural gas, especially in the devices shown for sealing oil wells from adjoining water-bearing strata and in the separation of heavy pressures of natural gas frequently occurring in oil wells in that state.

Fuel Oil.—Included under this head are all of the heavier oils for which no other market is available. Thus, the distillate which follows that used for kerosene is too heavy for use in lamps and too thin for lubricating purposes. The surplus, after supplying the demand for gas oil, is, therefore, sold for fuel oil. Again, in many fields—especially in California, Texas, and Mexico—the market will only take a small proportion of the products from crude oil; in fact, only a few years ago most of this heavy crude oil in these regions was burned as fuel without any attempt at refining, or at best after simply topping off the gasoline and kerosene.

The amount and the character of the oil available for heating purposes, which is a fair definition of fuel oil, fluctuate with the condition of the trade. Lately Mexico has been adding a large amount of heavy distillates for fuel purposes. The oils are obtained in the course of distilling the crude oil down to asphalt for paving and other purposes.

Prospect of Oil Fuel on Trans-Atlantic Lines.—The greatest obstacle to the development of a steady fuel oil trade in the United States is the uncertainty as to the amount of oil which can be sold for better purposes. The advent of large quantities of Mexican oils, however, has done much to give stability to the fuel-oil trade, and there is a very definite prospect that one or more trans-Atlantic lines will in the future use oil entirely as fuel, and the arrival in New York early in 1915 of a sailing barkque with the auxiliary Diesel engine system of propulsion is most significant for the future. With the development of more stable conditions in Mexico, it is altogether probable that imports of crude Mexican

oils and oils that have undergone slight preparation will be used largely in the merchant marine, and that the use of Diesel oils will also increase steadily—if not rapidly.

The above considerations make it necessary to point out the limitations which are made for fuel oils. As a matter of fact, almost any oil residue has been burned as fuel oil, especially under the boilers of stationary engines and on small merchant vessels. Very heavy residues, and even crude oils, have been burned successfully, but in considering the use of such oils in the navies of the world the limitation has been made that these oils must not flash at a lower temperature than 150° F., and where the oils are heavy the limitation is set that a higher temperature must not be required to bring the oil up to a maximum viscosity of 8° Engler (or 300° Saybolt) than the flashing point of the oil in question. This rule of not heating the oil above its flash point in order to make it liquid enough to successfully flow through pipes and be successfully sprayed under boilers has not been at all adhered to, either on land or on many of the merchant vessels. It is believed, however, that in all general use of fuel oils the above prescription of the United States Navy will be adhered to.

Improved Technology.—While the achievements above chronicled in connection with the utilization of California crude oil have been remarkable, they are, taken generally, merely in line with very profound changes in petroleum technology apparent in all parts of the United States. These changes concern, first of all, the general problem of converting one kind of derivative of petroleum into another kind, that is, breaking up one kind of hydrocarbon into another. This process in general has taken the name of cracking because, as a rule, these processes have aimed at the splitting up of hydrocarbons with a high molecular weight into simpler ones, such as the conversion of heavy gas oils or lubricating oils into gasoline, this line of conversion being comparatively easy to produce by the destructive action of heat. The fact should be emphasized, however, that this comparatively simple method of conversion is by no means the exclusive direction in which this problem is being attacked. The Burton process of splitting gas oils into "motor spirits" and the decompositions characteristic of the much more profound and interesting reactions of the process recently brought forth by the United States Bureau of Mines as resulting from the research work of Dr. Walter F. Rittman, have made it possible to produce in general as great a quantity of gasoline as the market can absorb. The present lines of study and technical achievement include problems of polymerization and of the addition of hydrogen or oxygen, or other gases, liquids and solids, to petroleum products for the synthetic production

many of the more valuable derivatives, for which the world has de-
nded upon natural animal or vegetable processes, such as the produc-
n of fatty acids, or which have been furnished by such complex re-
ions as the destructive distillation of coal furnishing carbolic acid
other phenols. These processes are emphasized because the progress
them is so rapid as to make petroleum chemical processes the chief
eresting feature of the year, and also because these processes promise
bring about profound changes in industrial conditions.

Oil Shales.—Considering the total supply of oil as influencing the
ure rate of production, it must be remembered that much more oil
n be obtained from oil shales in Colorado and Utah than all the known
fields can probably yield. This only takes into account shales richer
an the average Scotch shales.

RODUCTION OF PETROLEUM IN THE UNITED STATES BY FIELDS, 1909–1914
(In barrels) (*a*)

Field.	1909.	1910.	1911.	1912.	1913.	1914.
alachian	26,535,844	26,892,579	23,749,832	26,338,516	25,921,785	24,101,048
-Indiana	8,211,443	7,253,861	6,231,164	(*b*) 4,925,906	4,773,138	5,062,543
ois	30,898,339	33,143,362	31,317,038	28,601,308	23,893,899	21,919,749
-Continent	50,833,740	59,217,582	66,595,477	65,473,345	84,920,225	97,995,400
	10,883,240	9,680,465	10,999,873	8,545,018	8,542,494	13,117,528
fornia	55,471,601	73,010,560	81,134,391	(*c*) 87,272,593	97,788,525	99,775,327
rado and Wyom- g.	(*d*) 336,667	(*d*) 358,839	(*d*) 421,616	1,778,358	2,595,321	3,783,148
r fields	.....	.....	.....	.....	(*e*) 10,843	(*f*)7,792
Total	183,170,874	209,557,248	220,449,391	222,935,044	248,446,230	265,762,535

(*a*) Statistics of the U. S. Geological Survey. (*b*) Includes Michigan. (*c*) Includes Alaska. (*d*) udes Michigan and Missouri. (*e*) Includes Alaska, Michigan, Missouri, and New Mexico. (*f*) udes Alaska, Michigan and Missouri. (*g*) Includes Colorado and Wyoming.

Imports and Exports.—Imports of crude oil into the United States
1914 amounted to 710,351,077 gal., valued at $10,023,097, compared
h 713,100,321 gal., valued at $10,944,780, in 1913. Imports of
ned oil, mainly benzine, amounted to 14,095,832 gal., valued at
477,633, compared with 18,261,202 gal., valued at $2,052,231, in
3.

Imports.—The fact that the imports of crude oil fell in 1914 slightly
ow 1913 is attributable to the disturbed condition of Mexico. The
nand for these Mexican oils at Gulf and Atlantic coast ports is due
efly to the large amount of asphalt which can be obtained from them
low cost, and the facilities for refining these oils for the production of
halt and the usual other products were increased at Baltimore,
iladelphia and Bayonne, N. J., and a new refinery was in course of
nstruction at Curtis Bay near Baltimore, designed to handle these
xican oils exclusively. All the importations from Mexico, taken to-
her have barely opened the way for the consumption of Mexican oils,

either crude or prepared, for fuel oil on the Atlantic coast. The amount of imports which could be easily taken care of when this outlet assumes ordinary proportions will be many times greater than it is now.

Exports.—As shown by the table which follows, the disturbed foreign conditions interfered with the exports of mineral oils from the United States, except as to naphtha and residuum, both of which made new records for exports. The demand for naphtha for military purposes was greater than ever before, and under residuum is included fuel oil exported largely to England also for use by the Admiralty.

EXPORTS OF MINERAL OILS FROM THE UNITED STATES (a)
(In Thousands of Gallons and Thousands of Dollars)

Year.	Crude Petroleum.		Naphthas.		Illuminating.		Lubricating.		Residuum.		Totals.	
1900	133,161	$7,341	18,570	$1,681	739,163	$54,693	71,211	$9,933	(b)19,750	$845	981,855	$74,493
1901	127,008	6,038	21,685	1,742	827,479	53,491	75,306	10,260	(b)27,596	1,255	1,079,074	72,788
1902	145,234	6,331	19,683	1,393	778,801	49,079	82,200	10,872	(b)38,316	922	1,064,234	68,597
1903	126,512	6,782	12,973	1,519	691,837	51,356	95,622	12,690	(b) 9,753	282	936,697	72,629
1904	111,176	6,351	24,989	2,322	761,358	58,384	89,738	12,389	34,904	1,174	1,022,165	80,620
1905	126,185	6,086	28,420	2,215	881,450	54,901	113,730	14,312	70,728	2,128	1,220,513	79,642
1906	148,045	7,731	27,545	2,488	878,274	54,858	151,269	18,690	64,645	1,971	1,269,778	85,738
1907	126,306	6,334	34,625	3,676	905,924	59,635	152,029	19,210	75,775	2,528	1,294,659	91,383
1908	149,190	6,520	43,890	4,542	1,129,005	75,988	147,769	18,971	77,552	2,793	1,547,406	108,814
1909	170,338	6,028	68,759	5,800	1,046,401	67,814	161,640	20,016	121,966	4,180	1,569,104	103,838
1910	180,111	5,404	100,695	8,407	940,247	55,642	163,832	20,921	117,605	3,732	1,502,490	94,106
1911	201,843	6,165	137,295	11,483	1,112,295	61,055	183,320	23,337	133,979	3,882	1,768,732	105,922
1912	188,711	6,770	186,000	20,459	1,026,138	62,084	216,393	28,297	266,237	6,599	1,883,479	124,209
1913	194,470	8,448	188,051	28,092	1,119,441	72,042	207,639	29,608	426,859	11,125	2,136,460	149,315
1914	124,736	4,959	209,693	25,288	1,010,449	64,113	191,648	26,316	703,509	19,224	2,240,035	139,900

(a) In addition to the above, the following quantities of paraffin and paraffin wax were exported (1 = 1000); 1898, 166,317 lb. ($6,363); 1899, 181,861 lb. ($7,650); 1900, 157,108 lb. ($8,186); 1901, 151,695 lb. ($7,960); 1902, 175,268 lb. ($8,398); 1903, 204,120 lb. ($9,596); 1904, 174,582 lb. ($8,273); 1905, 160,836 lb. ($7,873); 1906, 173,504 lb. ($8,463); 1907, 207,504 lb. ($10,209); 1908, 141,667 lb. ($6,923); 1909, 181,328 lb. ($7,609); 1910, 199,913 lb. ($7,329); 1911, 214,018 lb. ($7,048); 1912 294,591 lb. ($9,603). 1913, 236,046 lb. ($8,177); 1914, 188,823 lb. ($6,435); (b) Reported in 1,000 bbl. of 42 gal.

California.—The amount of petroleum marketed in California during 1914 was greater than in any previous year, reaching 99,775,327 bbl., and the value was also the greatest on record, aggregating $48,066,096, an increase of 2.3 per cent. in quantity and 5.16 per cent. in value. This refers to the oil marketed. Statistics gathered by the Independent Producers' Agency and by the Standard Oil Co. of California both place the total product at between 103 and 104 million barrels. The difference between these statistics and those of the Geological Survey is undoubtedly due to different methods of considering the oil which was not turned over to the pipe lines.

California's oil trade reflects the fact that many contending influences in the state have prevented the industry from settling down to the condition characteristic of the eastern fields. Like Oklahoma, there is the possibility in California of producing a very large amount of petroleum, and the producers are in the habit of working up to the top limit of what can be sold and barely avoid such an excess as to demoralize

the prices. Meanwhile, the industry feels the effect of such great and unusual movements as the setting aside of a large area of oil land for the future use of the United States Navy; and the suits of the government to uphold the Presidential orders for the withdrawal of oil lands from entry. The efforts of great corporations (foreign) to secure large holdings in California sufficient for competition with American capital, and the rapid development of important processes for better utilization of oil have all contributed to an unsettled condition which will require years for adjustment, with the probability that, these larger problems once out of the way, more care can be taken in California than elsewhere in regulating the production to suit market conditions. Another embarrassing feature has been furnished by the remarkably great gushers which have distorted the best calculations of the operators who are engaged in adjusting the supply to the demand. This was well expressed in the *Oil, Paint and Drug Reporter* of Jan. 3, 1914, part of which is quoted below:

"The new year opens in California with so many big things taking place, it is difficult to segregate them. The way matters are shaping up at present indicates that there will be, in the near future, three immense marketing concerns that will control the entire business of the coast. The Standard Oil Co. stands first and the present organization is simply the outgrowth of a policy adopted when the Standard first entered California. It was the Standard Oil Co. then and it is the Standard Oil Co. now.

"What are apparently destined to be the other two controlling factors are the result of combinations of different elements that are now competing with each other as well as with the Standard. The Weir Syndicate, which already has the General Petroleum, is now maneuvering for the Union Oil Co., which controls the Independent Agency comprising 175 different producing companies. Such a combination, it is conceded, would place in the field an organization well equipped to compete with any other on the coast. The latest prospective 'big one' is the reported purchase of the Associated Oil Co., with its subsidiaries, by the Shell-Royal Dutch Co. This would corrall about all the remaining production of the state, because with their own production and that which they are buying from producing concerns on contract, the Standard, Union, Associated, and General Petroleum handle over 90 per cent. of the state's output, with the exception of the K. T. & O. Co. and the Santa Fe, which concerns produce oil for their own use.

"Thus the oil business of the state is being concentrated into the hands of three immense concerns—that is, providing all the deals now under way are consummated. Andrew Weir is still here in almost

daily consultation with Union Oil Co. officials, but no decision has yet been announced. The transfer of the Associated to the Shell interests is referred to below.

"It is generally believed that conditions would be improved should the negotiations referred to terminate successfully. The entire output of the state would be handled by these three concerns, and there would be enough competition to maintain a decent price for the producer. The coming of foreign capital into the field is taken as an indication also that new markets now untouched by California will be opened up to the coast fields.

"That these 'big doings' presage better times for the California producer is the firm belief of best posted oil men here.

"The unprecedented growth of the Standard Oil Co. of California is one of the wonders of modern industry. Only a little over a year ago the company found it necessary to increase its capital from $25,000,000 to $50,000,000. This was supposedly done because it was earning too much money on its then capitalization in view of the attitude of the government toward 'big business.' The business of the company, however, has expanded to such a degree during the year as to fully justify the increase. Even with the expenditure of millions of dollars in improvements, etc., the company was able to pay its stockholders $1,125,000 in dividends every quarter, or a total for the year of $4,500,000.

"The company is now planning other vast expenditures and has called a meeting of its stockholders to be held March 16 for the purpose of voting on increasing the capitalization from $50,000,000 to $100,000,000. The par value of the Standard's stock is $100, and it is now quoted at $285 in the market. The company now has a slight lead over its competitors on this coast, and the intention, no doubt, is to retain and increase that lead. The proposed concentration of other interests against the Standard has probably had something to do with the almost feverish activity noticed in every department of the Standard business, as shown in the increasing of its refinery and pipe-line facilities, and the wholesale development of the company's newly acquired holdings in the Midway and Fullerton districts.

"As regards production, the close of the year 1913 left a legacy of large gushers to be cared for in the region of Maricopa flats in the Sunset field. The first gusher of the Lakeview No. 2 Oil Co. flowed from 20,000 to 60,000 bbl. a day for the greater part of the year. The efforts to utilize this oil were very successful compared with the original Lakeview gusher of the Midway field. In fact, practically all of the Maricopa gusher oil was saved and, although a very profitable well to its owners, made a very unwelcome addition to the general supply. It ceased flow-

ing late in October, only to be replaced in December by the great K. T. & O. gusher."

The following table is a list of the important gushers developed during the year which yielded 1000 bbl. per day, or more:

CALIFORNIA GUSHERS OBTAINED IN 1914 (a)

District.	Company.	Section.	Production in Barrels.	Gravity.	Depth.
	January.				
Sunset-Midway	Spreckels Oil Co. (near Obispo Co.'s gusher).	.....	5,000	.....	.....
Sunset-Midway	Spreckels Oil Co. (No. 7, Maricopa Flats).	32–12–23	20,000	.....	.....
	February.				
Fullerton	Union Oil Co. (Stearns Lease Brea Canyon)	.....	3,000	29.0	3,900
	April.				
Sunset-Midway	North American Cons., No. 10	2–32–23	1,200	29.0	3,410
Sunset-Midway	Gen. Petroleum Co., No. 5	32–12–23	1,500	25.0	2,908
Sunset-Midway	North American Cons., No. 6	2–32–23	3,500	28.6	3,147
Sunset-Midway	Midland Oilfields, No. 2	32–12–23	1,200	25.0	3,000[a]
Sunset-Midway	Miocene Oil Co., No. 2	32–12–23	8,000	24.0	2,920[b]
Whittier-Fullerton	St. Helens Petroleum Co., Ltd., No. 2, (La Habra Valley).	18– 3– 9	1,000	22.3	3,267
	May.				
Midway-Sunset	Gen. Petroleum Co., No. 3	32–12–23	2,400	25.2	2,429
Midway-Sunset	Gen. Petroleum Co., No. 6	32–12–23	2,000	26.3	2,949
Midway-Sunset	Gen. Petroleum Co., No. 2	32–12–23	2,000	24.8	2,750
Midway-Sunset	Miocene Oil Co., No. 2	32–12–23	2,000	25.5	2,920[c]
Midway-Sunset	Kern Trading & Oil Co., No. 21	1–32–23	2,800	28.8	2,780
Midway-Sunset	Standard Oil Co., No. 5	16–36–24	1,500	27.0	2,745
Midway-Sunset	Lakeview Oil Co., No. 2, No. 1	4–11–23	20,000	20.0	3,013[d]
Coalinga	California Oilfields Co., Ltd., No. 16	2–20–15	1,600	28.6	3,748
Whittier-Fullerton	Standard Oil Co., No. 10 (Emery Lease)	13– 3–11	1,400	27.0	3,480
	June.				
Coalinga	Turner Oil Co., No. 7	2–20–15	3,000	31.0	3,832
Midway-Sunset	Kern Trading & Oil Co., No. 1	5–32–24	1,000	29.2	2,994
Midway-Sunset	Caribou Oil Mining Co., No. 4	28–31–23	1,000	28.5	3,120
Whittier-Fullerton	Brea Canyon Oil Co., No. 11-A	2– 3–10	1,300	26.0	3,910
	July.				
Midway-Sunset	Consol. Mutual Oil Co., No. 10	28–31–23	1,000	27.0	3,090
Midway-Sunset	Honolulu Cons. Oil Co., No. 3	10–32–24	1,500	30.0	2,594
Midway-Sunset	Midland Oil Fields Co., No. 4	32–12–23	6,000	25.1	3,390[e]
Coalinga	Turner Oil Co., No. 9	2–20–15	2,400	30.5	3,888[f]
	August.				
Whittier-Fullerton	Standard Oil Co	.....	3,000	29.0	3,500
Thirty-seven wells	completed during month with initial pro	duction of	10,105	bbl.	
	September.				
Four wells in Midw	ay-Sunset field on the Maricopa flat yielde	d a total of	34,000	bbl. da	ily.
	October.				
Midway-Sunset	Midland-Oilfields Co., No. 4	32–12–23	8,000	.....	[g]
	November.				
Fullerton-Whittier	Standard's Emery Lease, No. 12	.....	7,000	28.0	.....
.....	K. T. & O	11–20–15	5,000	.....	3,921
	December.				
Midway-Sunset	K.T. & O	1–32–23	30,000	26.0	.....

(a) *Oil, Paint and Drug Reporter*, January 4, 1915.

[a] This well came in on April 25 with an initial production of 10,000 bbl. [b] Sanded up a few hours after completion. [c] This well was completed during April with an initial production of 8000 bbl., but sanded up a few hours after completion. Later it produced regularly. [d] There were short periods when this well was thought to be producing at the rate of 50,000 bbl. daily. It ceased flowing late in October. [e] In this field the No. 2 well of the Miocene Oil Co., section 32–12–23, reported in May as a 2000-bbl. producer, later it yielded 8000 bbl. daily. [f] The No. 7 well of the Turner Oil Co., completed early in June with an initial production of 3000 bbl. daily; later it increased its flow to 4000 bbl. [g] Sanded up on October 3, after 107 days of activity, during which time its output averaged 8000 bbl. daily.

As mentioned on a previous page, the marketed production as officially stated by the U. S. Geological Survey was slightly below 100 million barrels. This doubtless omits some field storage included in the detailed figures given by the trade, as listed below.

THE OUTPUT OF THE VARIOUS FIELDS OF CALIFORNIA AND THE WELL RECORD FOR 1914 (a)

Field.	Production.		Rigs Compl. during Year.	Wells.	
	Year.	Per Day.		Completed.	Ab'd.
Kern River	7,030,545	19,262	9	15	2
McKittrick	3,820,857	10,468	12	9	5
Midway-Sunset	50,025,843	137,057	181	206	12
Lost Hills-Belridge	4,830,921	13,235	42	49	10
Coalinga	15,925,887	43,633	13	30	11
Lompoc-Santa Maria	4,303,080	11,789	9	6	2
Ventura Co.-Newhall	968,421	2,653	33	35	3
Los Angeles-Salt Lake	2,504,475	6,862	5	9	8
Whittier-Fullerton	14,130,548	38,714	81	62	2
Summerland	55,743	153	.....	.....	.....
Watsonville	27,375	75	.....	.....	.....
Total	103,623,695	283,901	385	421	55

Stocks on hand December 31, 1913, 47,870,177 bbl.
Stocks on hand December 31, 1914, 58,526,274 bbl.
(a) Standard Oil *Bulletin*.

The completions in the older California fields show a heavy decline, as shown by the following table:

COMPLETIONS FOR THE YEARS 1911–1914

Field.	1911.	1912.	1913.	1914.
Coalinga	192	142	64	30
Kern River	153	94	33	15
Lompoc-Santa Maria	19	23	16	6
Total	364	259	113	51

Colorado.—The region of Debeque afforded excitement by the drilling of a small producer which was eventually drowned out by water.

The Florence and Boulder fields showed, instead of the usual slightly declining tendency proper for their age, a gain from 188,799 bbl. in 1913, valued at $174,779, to 222,773 bbl. in 1914, valued at $200,894.

The production and value of petroleum in Colorado from 1904 to 1912, inclusive, is as follows:

Year.	Boulder.		Florence.		Total.	
	Quantity.	Value.	Quantity.	Value.	Quantity.	Value.
1904	18,167	$20,034	483,596	$558,001	501,763	$578,035
1905	10,502	11,502	365,736	326,104	376,238	337,606
1906	48,952	53,847	278,630	208,828	327,582	262,675
1907	68,353	75,188	263,498	197,625	331,851	272,813
1908	84,174	124,794	295,479	221,609	379,653	346,403
1909	85,709	129,812	225,062	187,900	(a)310,771	317,712
1910	42,186	63,420	193,482	174,332	(b)235,668	237,752
1911	37,973	50,393	187,341	175,763	(b)225,314	226,156
1912	15,304	19,130	190,498	180,281	(c)205,802	199,411
1913	8,341	10,426	160,304	142,782	168,645	153,208
1914	.....	.....	.....	.....	222,773	200,894

(a) Includes a small production in Garfield County. (b) Includes production of Garfield and Rio Blanco Counties. (c) Includes production of Rio Blanco County.

Illinois.—The expected decline was checked and surprisingly good results were shown; thus the total for 1913 was 23,893,899 bbl., with

a value of $30,971,910, while 1914 yielded 21,919,749 bbl., valued at $25,426,179. About 80 new wells were drilled in the northwestern corner of McDonogh County a few miles east of Plymouth. The wells were shallow—430 ft.—and failed to last satisfactorily. The new pool at St. Francisville, Lawrence County, gave wells producing as high as 1700 bbl. a day, and with good, lasting qualities, but the area of the pool proved quite limited. The Murphy well in Lawrence County began at 3300 bbl. a day and is still yielding over 300 bbl. a day. This has justified the considerable expense of drilling to 2000 ft. The decline in stocks of crude oil in Illinois caused the pipe lines to continue piping all the oil offered.

ILLINOIS OIL PRODUCTION, 1906–1914

Year.	Barrels.	Value.
Previous	187,660	$116,561
1906	4,397,050	3,274,818
1907	24,281,973	16,432,947
1908	33,686,238	22,649,561
1909	30,898,339	19,788,864
1910	33,143,262	19,669,383
1911	31,317,038	19,734,339
1912	28,601,308	24,332,605
1913	23,893,899	27,432,000
1914	21,919,749	25,426,179
Total	232,326,516	$178,857,257

FLUCTUATIONS IN PRICES, PER BBL., OF ILLINOIS OIL IN 1913 AND 1914 (a)

1913. Date.	Price per Bbl.	1914 Date.	Price per Bbl.
Jan. 1	$1.08	Jan. 1	$1.45
Jan. 3	1.11	Apr. 18	1.40
Jan. 27	1.14	Apr. 25	1.35
Feb. 1	1.17	Apr. 28	1.30
Feb. 6	1.20	May 1	1.27
Feb. 20	1.25	May 5	1.24
Apr. 15	1.30	May 12	1.21
Nov. 5	1.35	June 13	1.16
Nov. 19	1.40	Aug. 1	1.11
Nov. 21	1.45	Aug. 7	1.06
		Sept. 14	1.01
		Sept. 23	0.96
		Oct. 26	0.93

(a) *Oil, Paint and Drug Reporter.*

Kansas.—Drilling increased in 1913 and 1914, and the probability is that many new and old fields will be thoroughly explored during 1915. The production increased from 2,375,029 bbl., valued at $2,248,283, to 3,103,585 bbl., or an increase of 30.68 per cent., the total value being $2,433,074, in spite of a decline in the average price from $0.947 to $0.784 per bbl. The production of Kansas from 1909 to 1914, inclusive, is as follows:

Year.	Production in Bbl. of 42 Gal. (a)	Percentage, Increase.
1909	1,263,764	.....
1910	1,128,668	−10.7
1911	1,278,819	11.7
1912	1,592,796	24.5
1913	2,375,029	49.1
1914	3,103,585	30.7

(a) U. S. Geol. Surv. Statistics.

Kentucky.—Allen County furnished a 50-bbl. well in a new locality, causing much wildcatting in that part of the state, while a 75-bbl. well in Wolfe County was all the stimulus needed in the eastern part of the state to cause continued effort to find other pools. The result was a total of 502,441 bbl. in 1914, compared with 524,568 bbl. in 1913.

WELL RECORD FOR KENTUCKY FROM 1908 TO 1914, INCLUSIVE

Year.	Completions.	Initial Production, Bbl.	Dry Holes.	Gas Wells.
1909(b)	171	2,186	53	26
1910(b)	121	829	50(a)	.....
1911(b)	136	1,822	33(a)	.....
1912(b)	178	1,943	61(a)	.....
1913(b)	210	2,215	74	3
1914	179	1,570	56	4

(a) Gas wells not included.
(b) From Mineral Resources, 1912.

FLUCTUATIONS IN PRICES, PER BBL., OF SOMERSET AND RAGLAND, KY., OIL IN 1914 (a)

Date.	Somerset.	Ragland.
Jan. 1	$1.35	$0.70
April 20	1.30	....
April 22	1.25	0.65
April 27	1.20	....
April 29	1.10	....
May 11	1.05	....
June 16	....	0.60
July 15	1.02	....
July 28	1.00	....
Aug. 8	0.95	....
Aug. 12	0.90	0.57
Aug. 17	0.87	....
Aug. 20	0.85	0.55

(a) *Oil, Paint and Drug Reporter.*

Louisiana.—Louisiana's total increase was from 12,498,828 bbl., valued at $12,255,931, in 1913, to 14,309,435 bbl., valued at $12,886,897, in 1914, an increase of 14.49 per cent. in quantity and 5.15 per cent. in value. The gain came entirely from the northern portion of the field where the new De Soto production added 3,834,593 bbl. and more than offset the decline of over 2,000,000 bbl. in the Caddo field. The Red River district adjacent to the De Soto field also added nearly 500,000 bbl. Vigorous prospecting was required to prevent a

cline in northern Louisiana, but the results from new gushers were fficient to tempt the more venturesome wildcatters to remote regions the northeastern part of the state.

FLUCTUATIONS IN PRICES, PER BBL., OF LOUISIANA OIL IN 1914 (*a*)

Date.	De Soto.	Caddo, 38° and Above.	Caddo, 35°.	Caddo, 32°.	Caddo, Heavy.	Vinton.	Jennings.
- 1	.....	$1.05	$0.95	$0.90	$0.75	$0.85	.....
r. 6	.....	.....	.....	.....	.....	0.80	$0.90
r. 14	.....	.....	.....	.....	.....	0.70	0.85
r. 21	.....	.....	.....	.....	.....	0.60	0.75
il 1	.....	.....	.....	.....	.....	0.55	0.60
il 4	.....	.....	.....	.....	0.60	.....	.....
il 10	.....	.....	.....	.....	.....	0.45	0.50
il 15	.....	.....	.....	.....	.....	0.35	0.40
il 16	.....	.....	.....	.....	0.50	.....	.....
y 9	.....	1.00	0.90	0.85	.....	.....	.....
y. 8	.....	0.95	0.85	0.80	0.35	.....	.....
y. 12	.....	0.90	0.80	0.75	0.30	.....	.....
t. 1	$0.80	0.85	0.75	0.70	.....	.....	.....
t. 21	.....	.....	.....	.....	0.40	.....	.....

(*a*) *Oil Paint and Drug Reporter.*

New York and Pennsylvania.—As is characteristic of most branches the mining industry, considerable preparatory work is necessary for

RESULTS OF FIELD OPERATIONS IN NEW YORK AND PENNSYLVANIA, 1914

Field.	Comp.	Prod.	Dry.	Gas.
gany	268	446	17	40
dford	534	1,476	28	38
ldle Field	230	612	16	5
ango-Clarion	941	1,271	68	69
ler-Armstrong	276	659	79	19
Total	2249	4464	208	171
Total, 1913	3742	6964	363	227
Decrease	1493	2500	155	56

PRODUCTION AND VALUE OF PETROLEUM IN PENNSYLVANIA, 1904-14

Year.	Quantity, Bbl.	Value.
4	11,125,762	$18,222,242
5	10,437,195	14,653,278
6	10,256,893	16,596,943
7	9,999,306	17,579,706
8	9,424,325	16,881,194
9	9,299,403	15,424,554
0	8,795,662	11,908,914
1	8,248,158	10,894,074
2	7,837,948	12,886,752
3	7,963,282	19,805,452
4(*a*)	8,170,335	15,573,822

(*a*) U. S. Geol. Surv. statistics.

sponding to an increased demand evinced by the stimulus of increased ices. Thus the price of oil of Pennsylvania grade was high in 1913,

but the total production for the two states showed a decrease; while in 1914, with steadily declining prices, the production increased in Pennsylvania from 7,917,302 bbl. to 8,170,335 bbl. and decreased in New York from 948,191 bbl. in 1913 to 938,974 bbl. for 1914. But the money return was less in each state for 1914. The projects once put in motion for drilling or cleaning wells, a considerable production was necessary before these enterprises were paid for. In all probability the product would have shown marked increase but for the war, for the operators recognized that the falling prices, commencing the middle of April, were not even related to a greater or less product in the East, but solely to the excess production in the Mid-Continent field. Much of the oil is piped to the Atlantic seaboard. This market was seriously curtailed as soon as the European war was declared, and the pipe-line companies had difficulty in finding storage for their stocks. They reduced their runs to 25 per cent. of the production of each operator. The export situation improved rapidly, however, so that the pipe lines increased the proportion to 37.5 per cent. and then to 75 per cent.

FLUCTUATIONS IN PRICES, PER BBL., OF PENNSYLVANIA, CABELL, MERCER BLACK AND NEW CASTLE OIL IN 1914 (a)

Date.	Pennsylvania.	Cabell.	Mercer, Black.	Newcastle.
Jan. 1	$2.50	$2.07	$2.00	$2.00
April 17	2.40	1.97	1.90	1.90
April 20	2.30	1.87	1.80	1.80
April 22	2.20	1.77	1.70	1.70
April 27	2.10	1.67	1.60	1.60
April 30	2.00	1.57	1.50	1.50
May 11	1.90	1.47	1.40	1.40
June 1	1.80	1.40	1.35	1.35
June 16	1.75	1.35	1.30	1.30
July 15	1.70	1.32	1.27	1.27
July 28	1.65	1.25	1.22	1.22
Aug. 8	1.60	1.20	1.17	1.17
Aug. 12	1.55	1.15	1.12	1.12
Aug. 17	1.50	1.10	1.07	1.07
Aug. 20	1.45	1.05	1.02	1.02

(a) *Oil, Paint and Drug Reporter.*

Ohio and Indiana.—Drilling persisted in spite of the adverse conditions and an increase was shown in Ohio from 8,781,468 bbl. in 1913 to 8,536,352 bbl. in 1914. This resulted from the drilling in the central Ohio region stimulated by a 125-bbl. well struck in Hocking County early in the year.

Indiana showed an increase from 956,095 bbl. in 1913 to 1,335,456 bbl. in 1914. Sullivan County was the interesting locality, but its best production was over by the close of 1914.

PRODUCTION AND VALUE OF PETROLEUM IN INDIANA, 1903–1914 (a)
(In barrels)

Year.	Quantity.	Value.
.....	9,186,411	$10,471,127
.....	11,339,124	12,235,674
.....	10,964,247	9,404,909
.....	7,673,477	6,770,066
.....	5,128,037	4,536,930
.....	3,283,629	3,203,883
.....	2,296,086	1,997,610
.....	2,159,725	1,568,475
.....	1,695,289	1,228,835
.....	970,009	885,975
.....	956,095	1,279,226
.....	1,335,456	1,548,042

atistics of U. S. Geol. Surv.

FLUCTUATIONS IN PRICES, PER BBL., OF INDIANA OIL IN 1914 (a)

Date.	Indiana.	Princeton, Ind.
.....	$1.44	$1.35
.....	1.39	1.30
.....	1.34	1.25
.....	1.29	1.20
.....	1.24	1.15
.....	1.19	1.10
.....	1.14	1.05
.....	1.11	1.02
.....	1.06	0.97
.....	1.01	0.92
.....	0.96	0.87
.....	0.91	0.82
.....	0.88	0.89

il, *Paint and Drug Reporter.*

PRODUCTION OF OHIO BY DISTRICTS FOR THE LAST 12 YEARS

Year.	Lima Field.	Southeastern Ohio.	Mecca-Belden.	Total.
.....	14,893,853	5,585,858	575	20,480,286
.....	13,350,060	5,526,146	425	18,876,631
.....	11,329,924	5,016,646	90	16,346,660
.....	9,881,184	4,906,399	180	14,787,763
.....	7,993,057	4,214,298	93	12,207,448
.....	6,748,676	4,109,935	186	10,858,797
.....	5,915,357	4,717,069	367	10,632,793
.....	5,094,136	4,822,193	41	9,916,370
.....	4,535,875	4,281,173	64	8,817,112
.....	(a)3,955,897	5,013,051	59	8,969,007
.....	(a)3,817,043	4,964,425	.....	8,780,468
.....	(a)3,727,087	4,809,265	.....	8,536,352

cludes Michigan. All production in barrels of 42 U. S. gal.
. S. Geol. Surv. statistics.

FLUCTUATIONS IN PRICES, PER BBL., OF OHIO OIL IN 1914 (a)

Date.	North Lima.	South Lima.	Corning.	Wooster.
.....	$1.49	$1.44	$2.00	$1.91
.....	.....	.....	1.75	.....
.....	1.44	1.39	.....	1.81
.....	.....	.....	1.50	.....
.....	.....	.....	1.35	.....
.....	1.39	1.34	.....	.....
.....	.....	.....	1.25	.....
.....	1.34	1.29	.....	1.61

l, *Paint and Drug Reporter.*

FLUCTUATIONS IN PRICES, PER BBL., OF OHIO OIL IN 1914—(*Continued*) (a)

Date.	North Lima.	South Lima.	Corning	Wooster.
April 30	.....	.....	1.15	.....
May 1	1.29	1.24	.....	1.51
May 5	1.24	1.19	.....	.....
May 11	.....	.....	1.05	.....
May 12	1.19	1.14	.....	1.46
June 1	.....	.....	1.00	.....
June 17	1.16	1.11	.....	1.43
July 29	.....	.....	.....	1.38
Aug. 1	1.11	1.06	.....	1.33
Aug. 7	1.06	1.01	.....	1.28
Aug. 8	.....	.....	0.95	.....
Aug. 12	.....	.....	0.90	.....
Aug. 17	.....	.....	0.87	.....
Aug. 20	.....	.....	0.85	.....
Sept. 14	1.01	0.96	.....	1.23
Sept. 23	0.96	0.91	.....	1.18
Oct. 26	0.93	0.88	.....	1.15

(a) *Oil, Paint and Drug Reporter.*

Oklahoma.—In 1913 Oklahoma made the record production of 63,579,384 bbl., valued at $59,581,943. With the drilling craze in the Cushing field in 1914, various predictions were made, some taking the total product beyond 100 million barrels. The final figures of the United States Geological Survey, however, showed the amount of oil marketed in the state as 73,631,724 bbl., valued at slightly less than last year, that is $57,253,187, or a decline of 3.91 per cent. in the total value of the product. The average price dropped from $0.937 to $0.778. Most statisticians are inclined, however, to give credit in the production of the state to the stocks of oil produced by refining companies and held in steel storage, which the writer estimates at 14,000,000 bbl. This would bring the total production to over 87 million bbl., an estimate of the state's total which is more significant because this oil in storage played just as much of a part as the stock which had been sold to the pipe lines in depressing prices and effecting the unusual trade conditions which developed during the year.

Considering as a gusher any well yielding 1000 bbl. of oil per day, or more, over 100 gushers were obtained in the Cushing pool during 1914. A list of these gushers is given in the issue of January 4, 1915, of the *Oil, Paint & Drug Reporter*. Several of these produced 10,000 bbl or more per day. The temptation to increase drilling, especially in the Cushing region, was too great to be resisted, particularly as prices were higher than they had been for several years in the Mid-Continent field, and it was argued that even should prices decrease to half their value, there would still be profit from large wells, and experience had shown that large wells were to be expected. With this intense drilling, the field was extended chiefly to the northeast and northwest, the drilling being facilitated by the work of several unusually good geologists whose work

outlined the anticlinal system of the region early in the game. Results were uniformly successful. Production soon exceeded 200,000 bbl. a day from the Cushing field, and by the end of the year 250,000 bbl. a day could easily have been produced had the wells been drawn upon for their full capacity. Prices tumbled, but this had no effect upon the craze for more drilling, until finally, in accordance with the wishes of the more conservative operators in the state, the Oklahoma Corporation Commission complied with the resolutions adopted at a convention of more than 500 of the experienced operators, and prohibited any more drilling except where necessary for offsetting other producers or, of course, for protecting the terms of the lease. This order, and the persistent and conscientious work of Commissioner Henshaw, made successful a system for pro-rating the production of each operator so that no more oil was produced than could be taken care of. The wholesome effect of this effort at state control has been felt, and has beneficially regulated conditions in the Cushing field, and stocks increased only from 57.4 million bbl. in December, 1913, to 65 million bbl. at the end of 1914. In addition to this, however, considerable oil had been produced and was held by operators themselves, most of it in steel storage. This stock amounted to 14,000,000 bbl.

Oklahoma felt particularly the loss of a great portion of its outlet to the Atlantic coast, brought about by the declaration of war. This continued for the remainder of the year, to hamper the efforts of the pipe line companies to dispose of the oil and brought about a condition which made a further increase of stocks unjustified. The situation was further complicated by the advent of the Healdton pool where over 20 gushers yielded oil, much of which was above the average grade in sulphur, and much below the Cushing grade in refining qualities. This pool added as high as 380,000 bbl. a month, and necessitated a specially low price of 40c. for oil of this grade. Cushing's drilling craze also stimulated increased drilling in Osage, Washington, Muskogee, and Creek Counties, and the discovery of a new pool just south of the northern boundary of the state aided in demoralizing trade conditions in Oklahoma. At the end of the year a new pipe line from Cushing to the Gulf was projected by subsidiaries of the Royal-Dutch Syndicate. The high yield from the Cushing field continued during the first 6 months of 1915, then not only the increase in water from many of the Cushing wells warned of a coming decline, but a feature new to the oil industry was noted, namely, an increase in the percentage of sulphur in the oils of the northern part of the Cushing field. Never before has a radical change in the proportion of sulphur been noted in the oil from an individual well.

PRODUCTION AND VALUE OF PETROLEUM FROM OKLAHOMA SINCE 1909

Year.	Production, Bbl.	Value.
1909	47,859,218	$17,428,990
1910	52,028,718	19,992,660
1811	56,069,637	26,451,767
1912	51,427,071	34,672,604
1913	63,579,384	59,581,948
1914	73,631,724	57,253,187

FLUCTUATIONS IN PRICES, PER BBL., OF KANSAS AND OKLAHOMA, AND HEALDTON, OKLA., OIL FOR 1914 (a)

Date.	Kansas and Oklahoma.	Healdton, Okla.
Jan. 1	$1.03	$0.60
Feb. 2	1.05	.....
April 8	1.00	.....
April 10	0.95	.....
April 13	0.90	0.50
April 15	0.85	.....
April 20	.....	0.40
April 27	0.80	.....
April 30	0.75	.....
Sept. 12	0.65	.....
Sept. 22	0.55	.....

(a) *Oil, Paint and Drug Reporter.*

WELL RECORD FOR OKLAHOMA FOR 1914, BY MONTHS (a)

	Holes Completed.	New Production, Bbl.	Dry Holes.	Gas.
January	876	27,627	149	38
February	849	37,423	135	58
March	929	58,733	149	47
April	976	61,122	191	60
May	1,043	102,727	178	70
June	829	128,853	115	53
July	668	84,653	101	36
August	588	92,362	79	25
September	527	93,386	70	30
October	372	81,377	44	46
November	282	71,563	37	30
December	358	133,225	69	36
Total, 1914	8,297	973,550	1,324	529
Total, 1913	9,131	327,502	1,317	589
Difference	−852	+646,048	+7	−60

(a) *The Oil and Gas Journal.*

Texas.—In northern Texas active drilling was necessary to prevent a considerable decline in the Electra and other northern Texas fields. Drilling and search for new oil pools were active over the entire northern portion of the state. The Strawn field was developed early in 1915 in southern Texas. The Gulf field increased its production by deep drilling in many of the older fields with particular success at Sour Lake, and satisfactory results at Humboldt, Batson, and Saratoga. The total increase of the region was about equal to the increase of the Sour Lake pool. The total production of the state aggregated 20,068,184 bbl.

valued at $14,942,848, or $0.745 per bbl., against 15,009,478 bbl., valued at $14,675,593, or $0.978 per bbl.

West of the Pecos River, in Culberson County, eastern capitalists began drilling at Rustler Springs. Drilling was halted by a labor strike before the formation (Delaware) was penetrated in which oil was looked for, but even in the top of this formation an encouraging show of oil was obtained, of a grade slightly better than that previously found in this region.

FLUCTUATIONS IN PRICES, PER BBL., OF COASTAL TEXAS OIL IN 1914 (a)

Date.	Humble, Green.	Humble, Black.	Saratoga.	Sour Lake.	Spindletop.	Batson.	Dayton.	Goose Creek.	Markham.
an. 1	.....	.....	$0.90	$0.90	$0.95	$0.90	.....	.....	.....
an. 1	$0.70	$0.40	.....	.....	.....	.....	$0.65	$0.80	$0.60
lar. 6	0.65	.....	.....	0.85	.....	.....	.....	.....	0.55
lar. 14	0.75	.....	.....	0.75	.....	.....	.....	0.70	0.45
lar. 21	0.65	.....	0.80	0.65	0.85	0.80	0.55	0.60	.....
pril 1	0.60	.....	0.70	0.60	0.75	0.70	0.50	0.55	0.40
pril 10	0.45	.....	0.60	0.50	0.65	0.60	0.40	0.50	0.50
pril 15	0.35	0.30	0.50	0.40	0.50	0.50	0.30	0.40	0.40

(a) *Oil, Paint and Drug Reporter.*

Washington.—Seepages of high-grade petroleum are frequent in the Olympic Peninsula, especially near the mouth of Hoh River. Drilling was in progress there in 1914, and also near the mouth of Queniult River. The structure as worked out by Chas. T. Lupton, of the U. S. Geological Survey, is locally favorable for oil accumulations, near the mouth of the Hoh River.

West Virginia.—Production declined in spite of the most active drilling within and outside of the known pools, as rapidly as an unusually severe winter would permit. Drilling was especially active in Boone, Clay, and Wayne Counties, near the Kentucky line. Sardis district, in Harrison County attracted the drillers by yielding a 200-bbl. well in May. Drilling continued all the year in the new weir sand in Elk district, Kanawha County. The total product was 9,680,033 bbl., valued at $18,468,540.

PRODUCTION AND VALUE OF PETROLEUM IN WEST VIRGINIA, 1903–1914 (a)
(In barrels)

Year.	Quantity.	Value.
903	12,899,395	$20,516,532
904	12,644,686	20,583,781
905	11,578,110	16,132,631
906	10,120,935	16,170,293
907	9,095,296	15,852,428
908	9,523,176	16,911,865
909	10,745,092	17,642,283
910	11,751,871	15,723,544
911	9,792,324	12,767,293
912	12,126,137	19,927,721
913	11,562,730	28,828,814
914	9,680,033	18,468,540

(a) Statistics of U. S. Geol. Surv.

Wyoming.—Grass Creek, in Hot Springs County, gave more interesting results than any other region in the state. The Ohio Oil Co., the Valentine Co., and the Midwest Refining Co. developed several wells. They will yield 1000 bbl. a day, and will be piped to the refineries at Casper. High gas pressures were also obtained. The gas will be utilized. At Casper the Ohio Oil Co. finished a pressure plant for producing gasoline from heavy residues. The railroads also use their residues for fuel.

WORLD'S PRODUCTION OF PETROLEUM IN 1913 AND 1914 AND TOTAL PRODUCTION 1857–1914, WITH PERCENTAGE OF PRODUCTION BY COUNTRIES (*a*)
(In barrels of 42 gallons)

	1913.		1914.		Total 1857–1914.	
Country.	Production.	Percentage.	Production.	Percentage.	Production.	Percentage.
United States	248,446,230	64.59	265,762,535	66.36	3,335,457,140	59.63
Russia	62,834,356	16.34	67,020,522	16.74	1,622,233,845	29.00
Mexico	29,902,439	6.73	21,188,427	5.29	90,359,869	1.62
Roumania	13,554,768	2.52	12,826,579	3.20	117,982,474	2.11
Dutch East Indies	11,966,857	3.11	(*b*) 12,705,208	3.17	138,278,392	2.47
India	7,930,149	2.06	(*c*) 8,000,000	2.00	73,979,919	1.32
Galicia	7,818,130	2.03	(*c*) 5,033,350	1.26	131,873,601	2.36
Japan(*d*)	1,942,009	0.51	2,738,378	0.68	27,051,158	0.48
Peru	2,133,261	0.55	1,917,802	0.48	14,306,972	0.26
Germany	(*c*) 995,764	0.26	(*c*) 995,764	0.25	12,965,569	0.23
Egypt	94,635	0.03	777,038	0.19	1,086,728	0.02
Trinidad	503,616	0.13	643,533	0.16	2,069,430	0.04
Canada	228,080	0.06	214,805	0.05	23,493,610	0.42
Italy	47,256	0.01	39,548	0.01	802,229	0.01
Other Countries	(*e*) 270,000	0.07	(*e*) 620,000	0.16	1,322,000	0.02
Total	384,667,550	100.00	400,483,489	100.00	5,593,262,936	100.00

(*a*) U. S. Geological Survey Press Bulletin. (*b*) Includes British Borneo. (*c*) Estimated (*d*) includes Formosa. (*e*) Includes 600,000 barrels produced Argentina.

PETROLEUM OUTPUT OF THE WORLD (*a*)
(In metric tons)

Country	1908.	1909.	1910.	1911.	1912.	1913.	1914.
United States	24,401,728	24,433,528	28,331,000	29,001,000	29,906,416	33,126,164	35,435,004
Russia	7,654,600	8,037,300	8,952,793	9,167,600	9,249,600	8,377,914	8,936,069
Mexico	587,000	405,000	542,400	968,277	2,646,000	3,453,658	2,825,123
Roumania	1,147,727	1,263,946	1,352,300	1,544,847	1,806,942	1,885,225	1,783,947
Dutch East Indies	2,348,000	1,497,275	1,700,000	1,670,688	1,520,000	1,534,223	(*b*) 1,628,872
India	568,000	905,336	863,615	907,684	1,001,316	1,057,355	(*c*) 1,066,666
Galicia	1,754,002	2,150,000	1,700,000	1,454,660	1,180,568	1,087,286	(*c*) 70,004
Japan(*d*)						258,934	365,117
Peru						284,434	255,706
Germany						(*c*) 132,769	(*c*) 132,769
Egypt						12,618	103,605
Trinidad						67,148	85,804
Canada						30,410	28,640
Italy						7,000	550
Other Countries	293,000	505,000	786,480	750,000	800,000	(*c*) 36,000	(*e*) 82,666
Total	38,754,057	39,197,385	44,228,588	45,464,856	48,110,742	51,351,136	52,800,542

(*a*) Computed from preceding table. (*b*) Includes British Borneo. (*c*) Estimated. (*d*) Includes Formosa. (*e*) Includes 80,000 metric tons produced in Argentina.

Foreign Countries

Until the outbreak of the European war, the development of all foreign oil fields was prosecuted with unusual activity, and, in general, war conditions interfered less than was expected, except in Galicia, where production and refining is thoroughly demoralized. The effect upon the United States was a serious curtailing of foreign shipments, but these exports were rapidly adjusted

North America

Canada.—The press has recorded from time to time the rise and fall in the Calgary region in Alberta, Canada. The interest has not altogether ceased. Few would have believed that on the extremely meager showing of oil made in the Dingman some 17 miles southwest of Calgary, such persistent energy in looking for oil could have been maintained. At a depth of over 2300 ft. a small showing was obtained of oil very light in color and gravity, and containing more than 60 per cent. of gasolene. It was not deposited from natural gas because it is high in paraffin wax. The presence of wax is consistent with the idea that the oil has most of its heavy oil and all of it unsaturated components by migration through shales. Subsequent wells have proved very small producers, but the field is worth patient investigation as a probable small source of high-grade oil. Even the additional amount of oil found on drilling the Dingman oil well a few feet deeper was of entirely too slight amount for the excitement which followed and where millions of dollars of money from British Columbia and the United States cities of the west coast were ready for investment, at entirely unreasonable prices in spite of the warnings of the Geological Survey and Bureau of Mines of Canada. Meanwhile slower but more carefully planned exploration has been going on to the north of Edmonton and at several points in British Columbia with much prospect that in a few years valuable oil fields will be developed in the region of the great tar sands of the Athabasca country. Naturally the development of the Dingman well and the natural gas to the east of Calgary, at Bow Island and Medicine Hat have led to large drilling, and the only profitable result is the yielding of some information as to the geology of this interesting region.

The oil fields of Ontario received a few valuable additions during the year, and further attention was paid to the possibilty of developing oil in New Brunswick, and of distilling the oil shales which are rich and abundant there. All of this interesting effort was negatived by the declaration of war.

PRODUCTION OF CRUDE PETROLEUM IN ONTARIO, CANADA, IN 1914

	Bbl.
Lambton	154,186
Bothwell	33,961
Dutton	2,189
Tilbury	18,530
Onondaga	2,437
Belle River	1,191
	212,494

In addition, 387 bbl. of light was produced from Calgary, Alberta.
The average price of Canadian oil was $1.59 per bbl.

Mexico.—Mexico has developed in two directions, increased shipping facilities and the development of a great gusher 75 miles from Tampico, in the Panuco district. Further, the staying qualities of the large gushers have proved more than satisfactory. Except for high taxation and other incidents of the Mexican civil war, the industry has developed surprisingly well. The history of Mexican oil has been well written by Charteris A. Stewart.[1]

Mexico suffered from war conditions through the entire year, otherwise the total production would have been limited only by the transportation facilities, and these were increased greatly by the completion of 22 out of the 25 new tank steamers built for the Anglo-Mexican or Lord Cowdray interests. Considering the chaotic conditions in Mexico, the product was surprisingly large, nearly as much as in the year before. This resulted simply from the better transporation facilities mentioned above. To be sure, several unusually large wells were added to the supply of the Aguila Co., and the Mexican Petroleum Co. also drilled in several very prolific gushers. The sensational feature of the year in this respect, however, was furnished by the Holland Co., when early in the year the Corona well No. 1 on the west side of the Panuco River, about 75 miles by the river from Tampico, came in with a production which was estimated by some as high as 200,000 bbl. a day. The oil, however, was somewhat difficult of measurement, as it was very heavy, about 12° B. gravity, and contained some water. In flowing into the improvised reservoir it was impossible to form an accurate idea of the quantity on account of the oil foaming. This froth doubtless caused some high estimates. The well, however, is probably third largest in Mexico, and may have yielded as high as 50,000 bbl. per day. The well was soon under good control and has remained so.

In spite of the temptation offered by the inflammable nature of the oil stock in Mexico, a surprisingly small amount of oil was lost due to incendiarism during these troubled times. Several much more serious fires were due, as usual, to lightning, which destroyed one of the large pumping stations of the Aguila Co. and set fire to the great Potrero

[1] *Eng. Min. Jour.*, May 9, 1914.

gusher of this company. Fear of damage to the well due to the war conditions resulted in an effort to shut in this mammoth gusher, but only with the result of starting oil flowing from many seepages around the well. The well is still burning, after months of effort to extinguish it. In the meantime, however, this surface fire has not prevented almost the usual quantity of oil from flowing through the pipe connections from the well to Tuxpam. The activity displayed by the Aguila, Mexican Petroleum, and "Penn-Mex.," and other companies in building reservoirs in the Tampico region and continuing development during most of the year, in spite of the strenuous field conditions, requires a hearty tribute to the courage and persistence of the oil operators in this field. During April it was necessary for practically all Americans, and many of the British and Dutch to leave the oil fields. For a time the oil wells in the Topila and Panuco fields were left practically in the hands of the local Mexican people. Much credit must be given to these men for remaining at their posts and preventing loss of oil and damage to rigs and pipe lines by fire.

PRODUCTION OF PETROLEUM IN MEXICO, 1907 TO 1914 INCLUSIVE

Year.	Production in Bbl.
1907	1,000,000
1908	3,481,410
1909	2,488,742
1910	3,332,807
1911	14,051,643
1912	16,588,215
1913	25,902,439
1914	21,188,427

SOUTH AMERICA

Argentina.—There are 21 pumping wells and 9 more drilling in the very limited district of Comodoro-Rivadavia, where the Argentine government has reserved the most evidently profitable field, and opened about one-fourth to private exploitation. About 80,000 metric tons or 600,000 bbl. was produced in 1914, the yield being of the heavy fuel grade. The wells are usually 1750 to 1900 ft. deep. Oil has been found in one at 1552 ft. For traction engines in the agricultural districts the crude oil is sold at $3 a bbl.

The Argentine government took much more active steps in 1914 toward the establishment of a rational policy for the development of the oil fields in the neighborhood of Comodoro-Rivadavia. The Congress, in addition to opening part of the land to private exploration, authorized the Hon. Pedro Roth, petroleum commissioner for the Argentine government, to visit the oil fields of the United States for the purpose of developing the very best methods applicable to the Argentine conditions. It is altogether probable that this region will be greatly developed in 1915.

These oil fields are well described by Vice-Consul Eli Taylor,[1] although the calculation of the production is obviously in error.

Bolivia.—Encouraged by the oil developments in Argentine, much effort has been made to secure capital for the development of promising seepages found over a large area near Espijos Spring, 36 miles from Santa Cruz. This is only one of many regions, interesting in regard to oil, covering most of the area between the Argentine border and the Madre de Dios River. Engineers of the Royal Dutch syndicate are now examining large concessions or "denouncements" in this area. The term "concession" applies in Bolivia to what is little more than an ordinary lease under the usual royalty of one-tenth or one-eighth.

Ecuador.—In Ecuador development work was checked by the refusal of the Congress to ratify the concession granted by the President of Ecuador to Lord Murray and his associates. It is evident from this action that in Ecuador, Colombia, and other South American countries, the system of granting concessions will be replaced generally in the future by the more business-like policy of leasing the lands in accordance with the best offers made. As a matter of fact, there is little difference in the two systems as carried on in these southern countries.

Peru.—The production of Peru declined slightly in 1914.

The development of the Peruvian oil fields in the northern part of the country along the coast continued during 1914, but owing to the war the petroleum output was reduced toward the latter part of the year. The Standard Oil Co. increased its interests in the field on the northern coast, and the International Petroleum Co. (Ltd.) was incorporated to accomplish the consolidation of the London & Pacific, the West Coast, and the Lagunitas. The Standard interests also have a large holding in what is known here as the Lobitos oil fields, the stockholders of which will be given an opportunity to join in the consolidation. Most of the crude oils in the Lobitos district, which is controlled by the Standard Oil Co., is shipped to California in its tank steamers to be refined, and later returned to supply the markets of Peru, Bolivia, and Chile with petroleum fuel. Peru consumes California oil to the extent of about 50,000 tons annually, the larger part of which is used by the oil-burning steamers of the Peruvian Steamship Co., which operate between Panama and Peruvian ports, with headquarters at Callao.

The Independent Italian Co., known as the Establecimento Industrial de Petroleo da Zorritos, with headquarters at Callao, continued to operate its valuable properties along the northern coast in the Province of Tumbez. This company, which is owned by G. Peaggio & Co., owns or

[1] *Daily Cons. and Trade Rep.*, May 27, 1915.

controls oil-producing properties of about 77 square miles in extent. The output is approximately 3,500,000 gallons a year.

The denouncement of petroleum claims is now prohibited by law, and an additional taxation of these properties by the Government is now being considered, which measures, should they be enacted into law, would materially affect the revenues and values of these properties.

The quantity and value of the various classes of mineral oils exported from Peru during 1914 were as follows:

Class.	Tons.	Value.
Benzine	28 759	$2,989,848
Gasoline	885	132,111
Crude petroleum	107.536	1,202,681
Total	137,180	4,324,640

Trinidad.—Oil exploration continued actively during the year, and many fine wells were drilled, yielding about double the quantity of oil produced in 1913, that is, 536,278 bbl.

The tendency of the wells to sand up was met more successfully. Attention has been especially directed to the lighter oils (sp. gr. 0.810) found in the deeper Rio Blanco sand. As stated by Mr. John Cadman, in the *Mining Journal*, "while the rate of development has not been as rapid as might have been expected, much good work has been accomplished, many difficulties have been overcome, many new problems have been solved, and sufficient work has been accomplished to unquestionably demonstrate the potential value of Trinidad as a source of petroleum."

The chief producing companies are: the Trinidad Lake Petroleum Co.; the United British Oil Fields, Ltd.; the United British West India Syndicate; the Trinidad Central, the Cruse Syndicate, the Venezuelan Oil Explosion Co.; and Messrs. Stollmeyer.

Venezuela.—In Venezuela the American interests drilling the Trinidad and Bermudez fields continued their active exploration over very great areas in northern Venezuela. The Caribbean Petroleum Co. drilling in the neighborhood of Maracaibo, and using as a guide for its drilling the old pitch lake in that neighborhood, obtained a fair yield of oil in its first well on the East side of the lake at 390 ft. This resulted in the usual great excitement attending a new oil field, and prices for the land increased many fold, and further drilling especially by the Venezuelan Concessions Co. and the Colon Development Co. will undoubtedly develop the field.

EUROPE

Great Britain.—In the Scotch shale industry the interest of the British Admiralty in obtaining a home supply for the Navy has led to unusual activity, and there was prospect of similar activity in the oil shale industry in France. This unusual stimulus to the Scotch oil shales was timely, for the over-production of oil in the United States and consequent low import prices in England made it an unprofitable year, compared to the previous one when profits ranged from 10 to 30 per cent.

The oil shales occur in Mid- and West Lothian and in the northeast corner of Lanarkshire. It is believed by Mr. R. G. McCully, secretary of the Scottish Mineral Oil Association, that the quantity of shale still available is sufficient to furnish the present annual production, about 3,000,000 tons of shale or 1,500,000 bbl. of crude shale oil, for many generations.

The chief products of the industry are: illuminating oils, naphtha and motor spirit, lubricating oils, batching oil, gas and fuel oils, paraffin wax, paraffin candles, and sulphate of ammonia. The companies engaged in the shale oil industry are: The Broxburn Oil Co., Ltd., Glasgow; Dalmeny Oil Co., Ltd., Dalmeny; Oakbank Oil Co., Ltd., Glasgow; Pumpherston Oil Co., Ltd., Glasgow; James Ross & Co., Philipstoun Oil Works, Linlithgow; Young's Paraffin Light and Mineral Oil Co., Ltd., Glasgow.

Hungary.—In 1908 the Austrian government decided to adopt oil burners for the locomotives of the state railways. Eight hundred locomotives were adapted for the new fuel, and 35 supply stations were installed along the northeastern lines to afford the necessary consumption estimated at 300,000 tons a year. The disappointing developments of the Galician oil industry, however, compelled a return to coal firing. Meanwhile the state is putting forth every effort toward the discovery of further oil deposits, especially in Hungary. In this connection rich petroleum deposits are rumored near Egbell at the shallow depth of only 600 ft. Natural gas also has been reported in the vicinity.

Persia.—Up to the beginning of the war active development work was in progress in the oil fields adjacent to the Red Sea, and oil exploration by an American company was also active over a long strip of country in Turkey, but this came to a standstill with the outbreak of war.

By a transaction between the British Admiralty and the Anglo-Persian Oil Co., the British government secured an important interest in an oil concession extending over a large territory with the object of immediate development, until blocked by war conditions.

Roumania.—In the early part of 1914 in Roumania and Galicia ex-

ploitation work was more active than usual, because of the loss of time in the previous year, due to mobilization of the Roumanian army. Over 40 new companies entered into the Roumanian oil fields. But with the beginning of hostilities, production in Galicia sank to a low level, while in Roumania a necessary call of the workmen again to army mobilization left that country without the force necessary for properly operating the oil fields.

The chief developments in production were in the Bana-Moreni field and in the Fierbatori pool, which is an extension of the Baicoi field. Important development began in this pool in February, and after exciting developments in April and June, a gusher of 5000 bbl. a day was struck in August. In the Bana-Moreni field the Astra-Romana Co. struck oil in well No. 28 at Bana-Moreni in February. This extended the field to the east, and well No. 30 of the Roumanian Consolidated also extended the field to the west. In March two more gushers increased production, and in August the Romana-Americana brought in No. 74 as a 12,000-bbl. gusher which continued active for several weeks.

The Astra-Romana Co. also opened up new territory in the region of Ochiuri in the department of Dambovitza. There are also good prospects of success in the drilling begun at Ceptura, Valea Telegei, and in the bed of the Cricox between Staropoleos and Bana.

The war caused suppression of work on the trunk pipe line from Baicoi to Constantza, but the work was started again by private subscription with a view to early completion of this important project.

	1913, Metric Tons.	1914, Metric Tons.
January	166,199	139,974
February	147,780	132,473
March	158,560	161,833
April	163,718	147,975
May	161,428	147,486
June	165,089	148,775
July	156,295	148,905
August	153,739	137,220
September	153,470	129,517
October	168,260	161,247
November	139,054	147,884
December	152,037	180,658
Total	1,885,619	1,783,947

Later, the prohibition of the export of crude petroleum from Roumania and restrictions placed upon the exports of refined products united in causing a decline in production. The home market can only absorb about 35 per cent. of the total output of Roumanian oil, and with the closing of the Dardanelles, rendering the great shipping facilities recently developed at Constantza useless, it is remarkable that the decline was not greater than from 1,885,619 tons in 1913 to 1,783,947

metric tons in 1914. That the restriction was not altogether due to the war is shown by the preceding table of production by months. The decline was more evident in the first months of the year than at the end, the only increase before the war period being in March:

PETROLEUM PRODUCTS MANUFACTURED IN ROUMANIA IN 1913 AND 1914 (a)
(In metric tons)

Months.	Total Crude Petroleum used in Manufacture.	Petroleum Products during 1913.				
		Gasoline.	Kerosene.	Lubricating Oil.	Residuals.	Total Products.
January	138,438	30,507	32,645	1,583	71,636	136,371
February	130,315	28,255	30,483	1,862	67,938	128,538
March	170,271	41,039	37,583	3,562	86,029	168,213
April	158,589	36,274	35,357	4,292	80,813	156,736
May	148,939	35,287	29,089	4,578	76,825	145,779
June	147,363	36,404	31,152	3,826	73,137	144,519
July	112,786	27,344	23,372	4,561	55,813	111,090
August	123,951	30,931	25,851	4,217	61,185	122,184
September	168,974	41,252	34,303	5,241	84,509	165,305
October	176,855	41,536	37,158	5,284	89,791	173,769
November	171,076	39,418	33,017	5,056	90,263	176,754
December	139,688	33,772	30,064	4,354	68,796	136,986
Totals	1,787,245	422,019	380,074	48,416	906,735	1,757,244

Months.	Total Crude Petroleum used in Manufacture.	Petroleum Products during 1914.				
		Gasoline.	Kerosene.	Lubricating Oil.	Residuals.	Total Products.
January	138,612	32,158	30,929	4,218	69,131	136,436
February	134,685	32,302	28,366	4,566	67,339	132,573
March	148,552	36,708	30,009	6,798	73,187	146,792
April	146,483	32,173	35,475	8,746	68,541	144,935
May	168,138	40,274	36,448	12,857	76,554	166,133
June	143,673	34,425	29,585	10,643	67,583	142,236
July	143,287	32,487	33,228	9,219	66,375	141,309
August	138,808	32,184	28,508	6,236	69,947	136,875
September	129,668	28,722	26,071	8,007	64,163	126,963
October	141,783	34,408	28,946	8,069	68,115	139,538
November	117,973	28,839	21,570	8,289	57,078	115,776
December	129,232	32,185	23,457	12,399	59,263	127,304
Totals	1,680,894	396,865	352,682	100,047	807,276	1,656,870

The average percentage of different products was as follows: Benzine, 23.6 per cent.; illuminating oil, 21.0 per cent.; lubricants, 5.9 (increase); residiuum, 48 per cent., loss 1.5 per cent. This average yield varies only slightly from year to year, in Roumania.
(a) *Moniteur du Petrole Roumanin.*

Russia.—In Russia, conditions were depressed by a disastrous strike, which, so far as can be determined at this distance, was based on political grounds and practically on no grievances. It caused reduced production while it lasted, and no sooner had these conditions improved than the call to arms depleted the operating force in the Russian fields, as had already been the case in Austria and Roumania. The total production for the year amounted to 67,020,522 bbl. of 42 gal. Exports of petro-

leum products decreased very materially, from 54,700,000 poods to 31,900,000, due largely to closing of the Dardanelles.

The Maikop region declined in production from 86,600 tons in 1913 to 71,400 tons in 1914. Shortly after the beginning of the year 1915 a new gusher stimulated activity in that region, and materially increased the rate of production.

PRODUCTION OF PETROLEUM IN RUSSIA, 1904–1914, BY FIELDS (*a*)

Year.	Baku.		Grosny.		Maikop.	
	Poods. (*b*)	Barrels of 42 gallons.	Poods.	Barrels of 42 gallons.	Poods.	Barrels of 42 gallons
1904	614,115,445	73,723,290	40,095,331	4,813,365	.....	.....
1905	414,762,000	49,791,356	43,057,052	5,168,914	.....	.....
1906	447,520,000	53,723,889	38,373,603	4,606,675	.....	.....
1907	476,002,000	57,143,097	39,214,612	4,707,637	.....	.....
1908	465,343,000	55,863,504	52,058,895	6,249,567	.....	.....
1909	492,500,000	59,123,650	57,033,015	6,846,700	.....	.....
1910	497,842,212	59,764,971	74,048,358	8,889,359	1,304,800	159.604
1911	434,310,329	52,138,095	75,189,591	9,026,361	7,933,936	952,453
1912	429,300,000	51,536,615	65,400,000	7,851,140	9,200,000	1,104,442
1913	340,538,000	48,563,985	73,659,265	8,842,649	4,802,300	576,507
1914	424,400,000	50,960,264	98,445,187	11,818,150	3,956,606	457,019

(*a*) Statistics 1904–1913 from U. S. Geological Survey.

Year.	Other.		Total.	
	Poods.	Barrels of 42 gallons.	Poods.	Barrels of 42 gallons.
1904	.....	.....	654,210,776	78,536,655
1905	.....	.....	457,819,052	54,960,270
1906	(*c*)4,721,000	566,747	490,614,603	58,897,311
1907	.....	.....	515,216,612	61,850,734
1908	(*d*)611,221	73,376	518,013,116	62,186,447
1909	.....	.....	549,533,015	65,970,350
1910	(*e*)12,708,290	1,525,604	585,903,660	70,336,574
1911	(*f*)33,876,295	4,066,782	551,310,151	66,183,691
1912	(*g*)62,700,000	7,527,011	566,600,000	68,019,208
1913	(*h*)24,593,000	2,952,341	447,592,565	60,935,482
1914	(*i*)29,312,000	3,518,848	555,524,093	(*j*)66,762,287

(*b*) 61.05 poods = 1 metric ton crude; 8.33 poods crude = 1 United States bbl. of 42 gal.; 8 poods illuminating oil = 1 United States bbl. of 42 gal.; 8.18 poods lubricating oil = 1 United States bbl. of 42 gal.; 9 poods residuum = 1 United States bbl. of 42 gal.; 7.50 poods naphtha = 1 United States bbl. of 42 gal.; 8.3775 poods other products = 1 United States bbl. of 42 gal., estimated; 1 pood = 36.112 lb.; 1 kopeck = 0.515 c.

(*c*) Produced in Bereki and Tchimion oil fields.

(*d*) Produced in Surakhany.

(*e*) Includes 10,613,909 poods produced in Surakhany, 1,392,306 poods produced in Sviatoi, 610,500 poods produced in Ferghana, and 91,575 poods produced in Taman.

(*f*) Includes 19,896,524 poods produced in Surakhany, 2,515,363 poods produced in Sviatoi, 10,205,740 poods produced in Tcheleken, and 610,500 poods produced in Ferghana.

(*g*) Includes 43,900,000 poods produced in Surakhany, 3,300,000 poods produced in Sviatoi, 13,300,000 poods produced inTcheleken, and 2,200,000 poods produced in Ferghana.

(*h*) Includes 4,733,000 poods produced in Sviatoi, 13,860,000 poods, produced in Balakany, and 6,000,000 poods produced along Trans-Caucasian Railway.

(*i*) Includes 16,655,000 poods produced in Ural, 5,878,000 poods produced in Sviatoi, 5,000,000 poods produced in Tcheleken and 1,789,000 poods produced in Ferghana.

(*j*) Estimated.

The decline in production of the old Baku region was very marked, and the comparatively slight increase in the total for Russia, less than 7

per cent., was due to the marked activity in the development of the new Ural-Caspian district, in which over 50,000 separate "exploration areas" have been surveyd in the Gurieff, Temir and Elbistchinsk districts. Of these, only fifteen have thus far been declared petroliferous but explorations are being made in Dos-Sor, Makat, Balchiker, Iskenir, Bliume, Akat-Kul, Ssik and Karaton areas. In the region of Dos-Sor 16,655,000 was produced from about 40 wells. Over 50 more are now in process of drilling. Two refineries in this new Ural-Caspain region are already delivering kerosene, fuel oil and other products, all of which, together with considerable crude oil for fuel purposes, is delivered to the interior of Russia. The yield of Tcheleken decreased to 5,000,000 poods, while the production of Grosny showed a remarkable increase of 40 per cent.

Early in 1915 the distribution of plots of ground to petroleum explorers was begun in the Ukhta area in the Petchora district of Archangel province.

Baku exports for the 12 months ending December, 1914 as compared with the corresponding period in 1913 are as follows:[1]

	Illuminating Oil.	Lubricating Oil.	Residuum.	Crude.	Benzine-gasoline.	Total.
1914.....	8,729,411	1,634,561	19,427,129	6,883,805	170,286	36,845,192
1913.....	10,228,788	2,821,638	24,015,207	6,854,070	407,164	44,326,867

Spain.—For many years seepages of very light petroleum have been known near Villa Martin, a small town 27 miles from Jerez. Interest was renewed in this region by an appropriation by the Spanish government for a thorough exploration of the field.

Africa

Continued efforts were made to find valuable oil fields in Algiers and Tunis. The production in Egypt amounted to 840,000 bbl.

Madagascar.—A company was formed to exploit the seepages for 15 miles along both flanks of an anticline about 12 miles west of the edge of the Archaen ridge and 50 miles from the west coast. A yield of several barrels was obtained in the first well before it was lost by water.

South Africa.—Definite prospecting by skilled experts was begun in South Africa, following the partial favorable report of Mr. E. Cunningham Craig.

[1] *Petroleum World.*

ASIA

China.—In the far east, 1914 has been a year of constantly increasing activity even in China. The contract made between the Standard Oil Co. of New York and the government of China was put in operation, and a force of geologists and topographers was actively engaged in the study of foreign oil indications and old producing properties, which rendered that country a tempting field for the oil explorer. Later in the year a large drilling force followed the explorers into the interior of China.

Japan.—In Japan, the rotary drilling outfit imported from California, and representing the highest skill in this branch of oil-well drilling, was particularly successful in bringing in gushers larger than had been found for many years. On May 25 a gusher was struck at a depth of 1368 ft. at Akita Ken that yielded several thousand barrels a day. Oil from the island of Formosa has proved of much interest, and the Japanese government will explore the island thoroughly. The oil contains a large proportion of aromatic hydrocarbons. The oil industry in Japan was prosperous throughout the year.

Queensland.—Based upon finding natural gas to the extent of 2,000,000 ft. per day in a well drilled for water to 3700 ft., the government has sought the advice of Sir Boverton Redwood, Mr. A. C. Veatch, and other eminent oil experts, who agree that exploring for oil and gas is justified. An engineer has been sent to the United States for men and an outfit.

Papua.—Evidence of petroleum along a coastal belt of 8 to 12 miles wide from the delta of the Purari River nearly to Yule Island has caused Dr. Arthur Wade to recommend to the Australian government that the resources be developed.[1]

East Indies.—The total production in the Dutch East Indies aggregated 258,480 tons, an increase of about 6000 tons. The changes in Burmah, and in the East Indies generally, were simply in the direction of developing further oil fields without any strikes of considerable importance, although the Indu-Burmah Petroleum Co. struck oil in three wells during 1914. They were located in the upper Chindwin district at Indawkindat township. One was quite a large gusher; the region is wild and almost uninhabited.

Special investigations of the oil resources of the Punjab, northwest frontier province and Baluchistan form part of the year's work of the Government Geological Survey,[2] especially in Assam.

Sarawak.—The Anglo-Saxon Oil Co. has more than doubled its force and obtained a corresponding increase in production in 1914.

[1] *Daily Cons. and Tr. Rept.*, July 8, 1912; March 4, 1914.
[2] *Daily Cons. and Tr. Rept.*, October 24, 1914.

Brunci.—Three companies are interested in exploring for oil at Jerudong, from the Tutong River to the northeast, and at Blait—all based on well-defined indications. The work is arduous.

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Natural Gas

The total product of natural gas approximated 600 billion cu. ft., valued at $90,000,000, but the exact figures for 1914 will not be available

until late in the year. They are collected by the U. S. Geological Survey only. In 1913 the product aggregated 581,898,239,000 cu. ft., valued at $87,846,677, or an average price of 15.1 cts. per thousand cu. ft. This price is taken at the place where the gas is first sold, sometimes this is at the well mouth, more frequently it is taken at the point where consumed, and includes a large item of transportation cost.

In the statistics referred to above two valuable distinctions are made. In the statement of the product the Survey establishes by statistical canvass the amount of gas actually produced in each state, and this is a problem of great difficulty. Again, it gives a statement as to the amount consumed in each state, also a problem requiring very difficult statistical analysis on account of the amount of gas trans-shipped from one state to another. Thus West Virginia leads in the production of natural gas, producing nearly half of the entire production of the United States, and Pennsylvania is second, the two states accounting for 364 billion cu. ft. out of a total of 581 billion cu. ft. On the other hand Pennsylvania leads in the quantity of natural gas consumed, taking care of about 180 billion cu. ft.; and even Ohio consumes more natural gas than West Virginia, which produces by far the greater quantity. By far the greater amount of this gas is "dry" gas, obtained from wells that are essentially natural-gas wells; but over one billion cu. ft. comes from wet gas, or casing-head gas, from wells chiefly valuable for the oil they produce. Such wet gas yields on the average from 2 to 3 gal. of gasoline per 1000 cu. ft., that is, more than half a million barrels of casing-head gasoline are obtained annually.

Every branch of the industry continued in a profitable condition. The production of gasoline from casing-head gas increased satisfactorily during the year, and its use by blending with heavier naphthas gave more satisfactory results.

Ohio.—In Ohio the center of interest shifted from the gas belt in central Ohio to the neighborhood of Cleveland, where the old shallow gas industry has changed to deep drilling by which hundreds of large producers have been obtained.

Over 400 wells have been drilled in the field. Nearly all of them show from 2,000,000 to 12,000,000 cu. ft. of gas per day, but the large number of wells causes rapid decline in the pressure.

At the end of the year as many as 175 wells were being drilled in this so-called Cleveland pool. Markedly successful results have taken their attention from the southern field in central Ohio so as to suspend much of the regular work there in favor of the Lakewood and West Park fields.

Kansas.—During the year the Kansas Natural Gas Co. was operated largely under the receivers, and this administration of a large gas company practically by the public has been of considerable mutual advantage in developing the many difficulties in the way of successfully operating a natural gas company, and bringing about sympathy that has been altogether lacking heretofore between producer and consumer. As a net result, the Kansas Company did not yield even operating expenses, not taking into account depreciation of plant and sources of supply, and it is probable that the appeal coming from the receivers for permission to charge higher rates for gas throughout Kansas will receive more favorable attention. It is interesting to note the statement by the receivers that the waste in distribution, even after the gas has been brought to Kansas City, has been as high as 29 per cent.

Montgomery County led in new gas production and, together with Chautauqua County, over 250 billion cu. ft. per day was obtained from new gas wells. Butler, Franklin, Labette, Wilson, and Neosho were the chief gas-producing counties of the state.

Oklahoma.—In Oklahoma the gas interests have been strengthened by the evidently large amount which can be obtained in the new pools, and also by the valuable work of the Bureau of Mines in demonstrating how overlying gas may be drilled through and saved by the use of mud-laden fluid. This work will be extended to aid all problems of the gas fields.

The new gas wells drilled aggregated in initial production more than 3½ billion cu. ft. per day, and it is entirely evident that the tendency to utilize all of this gas is much greater than it was a year ago.

Creek County furnished over 1 billion cu. ft. of new production, Cherokee County coming next with 800 million, Cushing with 600 million, and Osage with 300 million.

Texas.—New gas wells are being extended from Mexia to Waco and Corsicana, and from the Clay County fields to many smaller towns; in fact, there is quite often a tendency to utilize small amounts of gas wherever found as at Cooper, Texas, where gas obtained with an artesian flow of water has been piped to many houses in the neighborhood.

Wyoming.—At Little Buffalo Basin and the Oregon Basin fields, well developed in 1914 proved particularly rich in natural gas. They are located thirty miles southeast of Cody, Wyoming and, according to the State Geologist, L. W. Trumbull, there is a probability of the gas from this region being piped to Billings and possibly to Denver and Omaha. He estimates the capacity of the gas wells at 65,000,000 cu. ft. per day, at a pressure of about 1000 lb.

The Ohio Oil Co., the Midwest Oil Co., and the Valentine Co. are

now drilling in that field. One of the wells near Wiley was drilled nearly a year go, and has been flowing from 6,000,000 to 8,000,0000 cu. ft. of gas per day.

Foreign Countries

Hungary.—According to Mr. Wm. Coffin,[1] United States Consul General at Budapest, a deposit of natural gas has been discovered in the township of Temerin, in the southern part of Bacska County, Hungary. This is the third district in Hungary in which natural gas has been discovered, and there are evidences that it exists in other parts of the country and that the deposits are enormous. A law enacted in 1911 makes all natural gas deposits discovered in Hungary the property of the government, and any exploitation of them must be made with the permission and under the authority of the Minister of Finance. Landowners on whose land gas has been discovered or may be discovered in the future are entitled to a certain compensation from the Hungarian government.

Natural gas has been struck in the vicinity of Egbell, in Hungary, by bores put down in accordance with directions given by the American experts appointed by the Hungarian government for the purpose of investigating the geological and other conditions bearing on natural gas occurrences in the country.

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[1] *Daily Cons. and Tr. Rept.*, July 24, 1914. (Previous discoveries of natural gas in Hungary have been noted in *Daily Cons. and Tr. Rept.*)

PHOSPHATE ROCK

By W. H. Waggaman

The European war has seriously affected the phosphate industry, not only abroad, but in this country as well. Owing to disturbed conditions, accurate statistics concerning the production and consumption of phosphate-bearing materials have been difficult, and in some cases, impossible, to obtain, but the output of all fertilizers has been greatly curtailed, and it is very unlikely that the market will show much improvement until the cessation of hostilities abroad.

The world's production of phosphate rock in 1913 amounted to over 6,780,000 tons. In 1914 the total output so far reported was less than 4,000,000 tons. Of this amount the United States produced 2,752,971 tons and consumed, 1,823,978 tons. Thus, in spite of a great curtailment in output, this nation continues to hold its place as the foremost phosphate-producing country in the world.

Practically all of the phosphate rock marketed is treated with sulphuric acid (an equal weight, approximately) and manufactured into acid phosphate for the fertilizer trade. In the United States, however, particularly in the Middle West, raw, finely ground rock phosphate is used directly on the fields. While the amount thus consumed is but a small percentage of the whole, it has been growing steadily, until in the past year it reached 50,750 tons.

Numerous processes for producing soluble or available phosphates have been devised and patented from time to time, and some of them give promise of commercial success.

The quantity of phosphate rock consumed in such processes is as yet nearly negligible. Brief descriptions of several of these processes which have come into prominence during the past year are given further on. Taking up the phosphate deposits in the order of their present commercial importance they are as follows: the phosphates of the United States, including those of great value and extent in Florida, Tennessee, South Carolina, and the western states, Utah, Idaho, Wyoming and Montana, and deposits of lesser importance in Kentucky, Arkansas, North Carolina and Virginia; the deposits in northern Africa in Tunis, Algeria and Egypt; the deposits of the Pacific and Indian Oceans, including those of Ocean, Christmas and Pleasant Islands and the islands of the Marshall

and Society Groups; the phosphates of Russia; the phosphates of Belgium and France; the Peruvian guano deposits, and the many smaller deposits in various other countries.

The world's production of phosphates in 1914 is given in Table I.

UNITED STATES

The United States is not only the largest producer of phosphate rock, but has a known reserve supply far greater than any other country. Numerous estimates have been made from time to time on the tonnage of phosphate available for future use in this country but they have varied so widely that little importance can be attached to them. Owing to the irregular character of some of the American deposits, accurate estimates can be made only by the most careful prospecting. Such prospecting is frequently not warranted and is seldom done except immediately before actual mining operations are begun.

TABLE I.—PRODUCTION OF PHOSPHATE IN THE WORLD
(In metric tons)

	1907.	1908.	1909.	1910.	1911.	1912.	1913.	1914.
Algeria	315,000	452,060	351,491	(d)319,069	332,897	388,515	461,030	(g)239,600
Augaur Palan Iseln.	.....	.....	9,000	45,000	41,000	50,000	90,000	(g)60,000
Belgium	181,230	198,030	205,260	202,880	196,780	.....	(e)178,455	.....
Canada	680	1,622	998	1,341	506	.....	.....	.....
Christmas Island (d).	110,000	260,000	197,982	310,625	250,000	300,000	(f)150,005	.....
Dutch W. Indies								
Aruba	36,036	20,061	27,227	27,838	.....	.....	.....	.....
Curacao	.....	.....	.....	3,570	2,000	.....	1,850	.....
Egypt	.....	700	1,000	2,397	6,425	69,958	101,311	.....
France	375,000	485,607	397,903	333,506	312,204	330,000	335,000	.....
French Guiana	10,565	9,092	8,997	6,816	.....	.....	.....	.....
Makatea (d)	.....	.....	.....	.....	12,000	40,000	82,000	.....
Norway	1,830	1,771	1,364	903	.....	.....	.....	.....
Ocean Island	190,000	301,160	197,922	310,625	250,000	300,000	250,000	.....
Russia	11,290	14,786	12,906	15,293	10,200	25,000	25,000	.....
Spain	3,078	4,483	1,387	(d)2,840	3,520	3,292	3,548	.....
Sweden	5,317	(c)	(c)	.....	.....	3,292	.....	.....
Tunis	1,069,000	1,300,500	1,223,512	1,286,262	(a)1,446,633	2,057,498	2,284,678	(h)492,778
United States	2,251,459	2,413,032	2,503,186	2,724,849	3,260,626	3,216,046	3,068,604	2,752,971
Japan	1,721	740	3,781	1,042	2,271	7,849	19,047	.....

(b) Metric tons of phosphate of lime; in addition there were 315,200 cubic meters of phosphatic chalk in 1902, 350,250 cubic meters in 1903, 311,640 cubic meters in 1904, 80,380 cubic meters in 1905, and 119,450 cubic meters in 1906.
(c) Statistics not available.
(d) Figures furnished by Charles Michel, Paris.
(e) Exports.
(f) *American Fertilizer.*
(g) Exportation for first 6 months, 1914.
(h) Exportation for first 3 months, 1914.

The data given below, however, were compiled in 1913 with considerable care from figures obtained by consultation with mine operators and by direct observation and field investigations of the various deposits throughout the country. While they are not intended for accurate estimates they may be regarded as conservative. The figures represent rock grading

from 60 to 70 per cent. bone phosphate of lime. In the case of the low-grade phosphate in the West and the wash heaps of Florida, the material is figured to its equivalent in high-grade rock.

Even assuming that there are no new discoveries in the United States and that the average consumption during the life of the phosphate fields will be three times its present consumption, there is sufficient to last for over 1100 years, provided proper mining methods are employed, and means for utilizing the lower grade material are devised.

TABLE II.—RESERVE SUPPLY OF PHOSPHATE ROCK IN UNITED STATES

	Tons.
Utah, Idaho, Wyoming and Montana:	
High grade	2,500,000,000
High-grade equivalent of all grades	7,500,000,000
Florida:	
High-grade equivalent of all grades	354,300,000
High-grade equivalent of wash heaps	20,000,000
Tennessee:	
High-grade equivalent of all grades	115,075,000
S. Carolina:	
High-grade equivalent of all grades	10,000,000
Arkansas:	
High-grade equivalent of all grades	20,000,000
Kentucky:	
High-grade equivalent of all grades	500,000
	10,519,875,000

The production, consumption, and exports of phosphate rock in the United States for the past 4 years are given in the following tables.

TABLE III.—PRODUCTION OF PHOSPHATE ROCK IN THE UNITED STATES (a)
(In tons of 2240 lb.)

Phosphate.	1911.		1912.		1913.		1914.	
	Tons.	Value.	Tons.	Value.	Tons.	Value.	Tons.	Value.
Florida hard rock	474,094	$2,953,606	536,379	$3,218,274	510,811	$3,371,386	(b)309,689	$1,912,197
Florida land pebble	2,020,477	6,809,007	2,043,486	7,101,186	2,043,403	6,334,549	1,829,202	5,442,547
Florida river pebble	.....	.....	.....	.....	.....	.....	.....	.....
Total, Florida	2,494,571	$9,762,613	2,579,865	$10,319,460	2,554,214	$9,705,935	2,138,891	$7,354,744
S. Car. land rock	(b) 169,156	$673,156	(b) 131,490	$524,760	109,333	$440,588	156,363	$496,907
S. Car. river rock	*nil*	.....	.....	.....	.....	.....	.....	.....
Total, S. Carolina	169,156	$673,156	131,490	$524,760	109,333	$440,588	156,363	$496,907
Tennessee	542,761	$1,918,489	443,065	$1,710,000	439,822	$1,649,303	451,942	$1,694,782
Other States	(c) 10,505	39,882	(b) 11,612	46,450	5,050	18,167	5,775	17,223
Total, U. S.	3,216,993	$12,394,140	3,166,032	$12,600,670	3,108,419	$11,813,993	2,752,971	$9,563,756

(a) Statistics collected by MINERAL INDUSTRY, except as otherwise noted. (b) Reported by the U. S. Geol. Survey. (c) Idaho, Utah and Wyoming.

TABLE IV.—STATISTICS OF PHOSPHATES IN THE UNITED STATES (a)
(In tons of 2240 lb.)

Year.	Production.	Imports.	Exports. (b)	Consumption.
1905	1,933,286	82,072	934,940	1,080,418
1906	2,052,742	46,228	904,214	1,194,756
1907	2,251,459	25,896	1,018,212	1,259,143
1908	2,375,031	26,734	1,196,175	1,205,590
1909	2,463,766	11,903	1,020,556	1,455,113
1910	2,681,938	19,319	1,083,037	1,618,220
1911	3,216,993	16,153	1,246,577	980,569
1912	3,166,032	28,821	1,206,520	1,988,333
1913	3,062,975	26,408	1,338,450	1,724,525
1914	2,752,971	15,078	928,992	1,839,057

(a) Production statistics of 1901 and subsequent years, except 1905–1913, are those of the U. S. Geological Survey and are based on marketed products. (b) Neglecting the insignificant exports of foreign product.

The imports of fertilizers of all kinds into the United States were as Tables V and VI:

TABLE V.—IMPORTS OF FERTILIZERS INTO THE UNITED STATES
(In tons of 2240 lb.)

	1910.		1911.		1912.		1913.		1914.	
	Quantity.	Value.	Quantity.	Value.	Quantity.	Value.	Quantity.	Value.	Quantity.	Value.
Phosphates (crude)	17,668	$204,340	18,980	$203,326	20,685	$179,605	23,478	$184,204	15,078	136,526
Apatite	.....	.....	.....	.....	80	1,140	2,930	22,515	20	300
Basic slag	8,856	75,705	13,150	89,175	11,751	110,229	15,124	145,477	74,588	1,501,542
Blood char (lb.)	.....	347	661	347	.....	.....	2,954	333	(b)	(b)
Blood (dried)	.....	224,381	.....	448,739	.....	220,297	.....	86,065	(b)	(b)
Blood (dried) when soluble), lb.	5,562	351	4,897	280	7,701	423	6,412	339	(b)	(b)
Bone char	.....	18,232	.....	22,448	.....	20,414	.....	12,484	(b)	(b)
Bone dust	37,730	882,407	44,635	1,134,443	118,535	913,023	33,919	818,306	36,022	890,672
Guano	46,819	819,879	31,740	625,044	34,856	685,140	16,461	313,898	25,562	762,688
Kainit	470,241	2,268,363	586,474	2,637,105	479,417	2,400,590	466,184	2,349,689	329,611	1,550,879
Keiserite	5,179	10,484	2,100	3,564	7,545	17,689	10,800	44,770	(b)	
Cyanite	8,735	44,303	400	1,994	900	7,535	612	7,949	(b)	
Manure salts	90,933	928,357	160,105	1,265,867	185,682	1 824,426	172,557	1,798,973	168,426	1,842,649
Potash (muriate)	195,927	5,640,541	214,284	6,449,575	242,033	7 235,729	223,836	6,737,757	168,509	5,740,893
Potash (sulphate)	24,485	1,399,915	53,139	1,952,370	50,551	1,853,236	48,022	1,798,369	36,246	1,568,704
Nitrate of soda	542,333	16,548,036	546,394	17,101,155	481,786	15,427,904	586,315	20,713,375	543,715	15,228,671
All other fertilizers	196,901	3,129,813	191,975	3,914,508	169,283	3,527,646	115,257	2,190,816	.....	3,553,793

(a) Not reported.
(b) Included in figures of "All other fertilizers."

Florida.—The phosphates of Florida still hold first place among the more important deposits known to the world, located in one of the southern states where fully 80 per cent. of the fertilizer manufactured in this country is consumed, and having excellent transportation facilities both by rail and water, they are well fitted to supply our domestic needs. Moreover, their richness and even grade will no doubt continue to afford them a market in European countries for many years to come.

In 1913, 28 companies were engaged in mining Florida phosphate. The total output for that year, based on the material marketed, was 2,554,214 tons. In the early part of 1914, 23 companies were actively engaged in mining operations, but on the breaking out of the European

war a gradual curtailment of production ensued, resulting finally in the closing down of many plants altogether. At the close of 1914 only 19 out of 54 plants were in operation. The total production for 1914 was 2,138,891 tons.

TABLE VI.—EXPORTS OF FERTILIZER MATERIALS IN 1913 AND 1914

	1913.		1914.	
	Quantity.	Value.	Quantity.	Value.
Sulphur or brimstone, crude, tons	89,221	$1,599,761	98,153	1,807,334
Phosphate rock, not acidulated:				
High-grade hard rock, tons	473,533	4,735,330	281,806	2,818,060
Land pebble, tons	891,263	5,255,416	681,241	3,948,079
All other, tons	1,712	5,834	1,067	5,513
All other fertilizers, tons	72,747	1,666,755	63,554	1,311,227
Exported to—				
Belgium	137,331	885,407	91,797	591,308
France	120,724	740,482	108,760	653,637
Germany	348,103	3,018,457	219,732	1,886,437
Italy	102,147	635,140	83,824	506,776
Netherlands	195,675	1,516,047	115,760	894,101
United Kingdom	179,239	1,158,066	138,899	827,502
Other Europe	182,037	1,450,538	149,300	1,115,899
Canada	39,069	700,654	40,479	752,357
West Indies and Bermuda	32,849	785,839	23,956	457,571
Japan	99,255	659,831	48,055	287,988
Other countries	2,826	112,874	7,106	109,233
Cottonseed meal, lb	1,005,977,200	13,735,835	999,467,765	13,033,872

Since practically all of their product has heretofore been shipped abroad, the operators in the hard rock field suffered more by the European war than those in the pebble regions of Florida or in Tennessee.

In 1914 the marketed output was 309,689 tons, as against 510,811 tons in 1913. Only 5912 tons of the total quantity marketed in 1914 was consigned for domestic consumption. Nearly all of the shipments were made during the first 7 months of 1914. Only one small shipment of 650 tons has been made so far in 1915, and mining operations have practically ceased.

The average price of hard rock in 1914 at ports in Florida was $6.48 per ton.

The European conflict has caused a serious curtailment in the production of pebble phosphate. The output from these fields has heretofore been about equally divided between the foreign and domestic markets. High freight rates, lack of steamers, and the difficulty of entering certain foreign ports have cut down the export trade to a minimum. The domestic market has also been seriously affected on account of financial stringency in the South, due to the lack of market for last year's cotton crop.

The pebble phosphate on the whole is of lower grade than the hard rock, averaging about 70 per cent. bone phosphate of lime. Several concerns, however, with exceptionally rich deposits have been guarantee-

ing their product to run as high as 75 to 77 per cent. In the early part of 1914, 13 companies were engaged in mining or shipping pebble phosphate, but many of these were closed down entirely at the end of the year and others were running only intermittently. Two new companies which had practically completed their plants decided to await a more favorable time before beginning mining operations.

Most of the pebble phosphate is sold on a guarantee of 68 per cent. bone phosphate of lime, and a maximum of 4 per cent. iron and alumina. In 1914 the exports amounted to 625,821 tons, while 1,203,381 tons was consumed in the United States. The average price for the year was $3.38 per long ton at ports.

The production of Florida phosphates for the past 5 years is given in Table VII.

TABLE VII.—STATISTICS OF FLORIDA PHOSPHATE
(In long tons)

Year.	Production.			Total Shipments.	Domestic Consignment.	Exports.
	Hard Rock.	Pebble.	Total.			
1910	392,088	1,637,709	2,029,797	2,081,936	1,014,473	1,067,463
1911	474,094	2,020,477	2,494,571	2,456,440	1,290,779	1,165,661
1912	536,379	2,043,486	2,579,865	2,422,932	1,219,927	1,203,005
1913	510,811	2,043,403	2,554,214	2,554,214	1,130,764	1,363,450
1914	309,689	1,787,597	2,138,891	2,138,891	1,209,898	928,993

Tennessee.—Tennessee is particularly well situated for the distribution of fertilizer material to the South and Middle West, but is not as favorably located at Florida for the exportation of phosphate rock. In 1914, 10 companies were engaged in mining Tennessee phosphate. Their total marketed output for the year was 451,942 tons, an amount in excess of that marketed in 1913, when 439,822 tons was produced.

Practically all of this rock was consumed in the United States, so the European struggle had but little effect on the industry. The average price of Tennessee phosphate for 1914 was $3.75 per ton f.o.b. mines.

During the past few years the mining of brown rock phosphate has undergone quite a revolution. The old pioneer methods have been replaced by modern schemes which not only save more material but have made it possible to profitably re-work the old dump heaps and waste ponds. The life of the Tennessee phosphate fields has thereby been considerably prolonged.

South Carolina.—The production of phosphate in South Carolina in 1914 amounted to 156,363 tons, an amount considerably greater than that produced in either of the two preceding years. The average grade

of the rock is 60 per cent. bone phosphate of lime, and its average price f.o.b. mines during the past year was $3.05 per ton.

It is obvious, therefore, that the rock is unable to compete with the higher grade product from other sources, except for local consumption. Much of the rock is shipped to Charleston and made into double acid phosphate, a concentrated fertilizer.

South Carolina phosphate is mined by first removing the overburden with steam shovels, then digging out the phosphate stratum thus exposed. The material is then loaded on flat cars, carried to the washer and washed, screened and dried.

Utah, Idaho, Wyoming and Montana.—The phosphate deposits in these states are the most extensive ever discovered. The rock is of Carboniferous age and occurs as a bedded deposit having an oolitic structure and varies in color from light gray to jet black. The various beds range in thickness from a few inches to 6 ft. or more, with an average grade of about 70 per cent. bone phosphate of lime.

In December, 1908, the Secretary of the Interior withdrew from entry 7000 acres of land in this region, pending a detailed survey of the area. Much of this land has since been restored as non-phosphatic, but large areas not included in the original withdrawals were found to contain phosphate rock and were therefore added to the reserve. The withdrawals outstanding January 1, 1914, according to the figures of the United States Geological Survey, were 2,870,671 acres in Florida, Idaho, Montana, Utah and Wyoming.

Claims, however, had already been filed on much valuable phosphate land before the withdrawals were made. Much litigation caused by the filing of both lode and placer claims on the same property has finally resulted in a decision that such deposits should be classified as lode. A bill, however, recently passed Congress, validating placer locations which had been made in good faith, and filed on property on which no conflicting lode claim had been filed. Another bill which passed the House in September, 1914, provides for the leasing of phosphate lands on the payment of royalty to the government.

Several companies control very rich deposits of phosphate rock in Utah, Idaho and Wyoming, but up to the present time the limited use of fertilizer in the West and the heavy cost of hauling the material to a more ready market have prevented the development of these fields.

The fast growing necessity of preventing the escape of sulphur fumes from the smelters in Montana and Utah, however, may force the copper producers to manufacture fertilizer material. By producing concentrated phosphoric acid or double acid phosphate they may be able to compete with the Eastern phosphates.

In the latter part of February, 1915, the Montana Phosphate Co. was organized with a capital stock of $2,000,000. The company has secured leases on 200 acres of land in the vicinity of Philipsburg and Maxwell and planned to erect a plant at the latter place.

In 1914 three companies were mining phosphate intermittently. One of these was grinding phosphate and selling it in California for direct application to the field. The total production for 1914 amounted to 5775 tons, as against 5053 tons reported by the U. S. Geological Survey for 1913. The average price of the rock f.o.b. cars was $3 per ton.

Arkansas.—No production has been reported from Arkansas since 1912. The mines near Batesville have been shut down, as it has been found more practicable to supply the demand for phosphate just west of the Mississippi from the higher grade deposits of Tennessee.

Kentucky.—Several small deposits of high-grade phosphate rock have been found in the Ordovician limestone in Woodford, Scott, Fayette and Jessamine Counties. Early in 1912 a plant for treating phosphate rock was erected by the Central Kentucky Phosphate Co., 2 miles from Midway, a little town between Frankfort and Lexington. Leases were taken on a number of the farms in the vicinity and mining operations begun. The company contracted to furnish a certain tonnage of high-grade rock to one of the large fertilizer companies and also engaged in the production of ground rock phosphate. After struggling along for over 2 years the company went into the hands of a receiver and was bought in by the Charleston Mining and Manufacturing Co. in the summer of 1914. The production from Kentucky during 1914 was only a few thousand tons.

In Kentucky, phosphate occurs in thin close-grained plates, brownish gray in color and resembling closely the brown rock phosphate of Tennessee. Much of the rock will run 75 per cent. bone phosphate of lime.

Phosphates in Foreign Countries

Africa

The phosphates of northern Africa, including those of Tunis, Algeria, and Egypt are next in importance to those of the United States. Whereas the material on the whole is not as high grade as that from Florida and Tennessee, its nearness to the European market has made it in recent years a serious competitor of the American product for the export trade.

Since the outbreak of the war, however, the production from all African deposits has fallen off tremendously, due not only to lack of sufficient market for the material, but because the operators and laborers have joined the French army. The statistics for 1914 are very in-

complete, owing to disturbed conditions; the production in 1913 amounted to 2,328,777 tons, as against 2,381,473 tons in 1912.

Tunis.—Tunis has an annual output second only to that of Florida, during the first 3 months of 1914 the exportations having amounted to 492,778 tons. The exportations for the year 1913 were 1,803,564 tons.

The main phosphate district is in the vicinity of Gafsa, which is connected with the port of Sfax by a railroad 150 miles long. The phosphate occurs as gigantic lenses of considerable thickness and ranges in grade from 58 to 68 per cent. bone phosphate of lime. The mining is done by open cuts.

The "Societe des Phosphates de Gafsa," which controls all the phosphate properties in the Gafsa region, is the largest single producer of phosphate in the world, and up to 1914 has continually increased its annual output. The other companies in Tunis are the "Societes des Phosphates Tunisiens," and the "Compagnie des Phosphates du Dyr."

The average price of Tunisian phosphate in 1914 up to the time of the war was about 10.2 cts. per unit of P_2O_5.

Algeria.—The phosphates of Algeria are of the same type as those of Tunis, but have not been developed to the same extent. The exportations for the first 6 months of 1914 amounted to 239,690 tons. The total production for the previous year (1913) amounted to 461,030 tons. The most important company mining in Algeria is the Compagnie des Phosphates de Constantine. Its production in 1913 amounted to 314,168 tons. Other companies operating in these fields are the "Compagnie Centrale," the "Compagnie Algerienne des Phosphates de Tocqueville," and the "Compagnie de M'Zaita."

The average price of Algerian phosphate in 1914 at Mediterranean ports up to the time of the war was 10.2 cts. per unit of P_2O_5.

The shipments of phosphate from Tunis and Algeria since 1895 are given in Table VIII.

TABLE VIII.—SHIPMENTS OF PHOSPHATE ROCK FROM ALGERIA AND TUNIS
(In metric tons)

Year.	Algeria.	Tunis.	Year.	Algeria.	Tunis.
1895	104,603	.....	1905	347,747	529,645
1896	142,524	.....	1906	302,262	747,303
1897	227,870	.....	1907	343,085	956,998
1898	269,572	.....	1908	362,890	1,270,020
1899	286,681	65,209	1909	351,491	1,224,822
1900	277,896	171,288	1910	319,069	1,286,262
1901	278,185	178,019	1911(a)	332,897	1,446,633
1902	265,964	266,553	1912(a)	388,515	1,923,000(b)
1903	301,112	360,621	1913	461,030	1,803,564
1904	344,969	457,133	1914	239,600(c)	492,778(d)

(a) Figures furnished by Charles Michel, Paris. (b) Estimate. (c) Exportations for first 6 months of 1914. (d) Exportations for first 3 months of 1914.

Egypt.—Phosphate deposits have been found in various parts of the Egyptian desert regions and in the valley of the Nile. The rock is of Cretaceous age and varies in grade from 30 to 68 per cent. bone phosphate of lime.

Mining is being conducted in two localities; in the Sapaga district near the Red Sea coast and in the Sibaia district on both sides of the Nile. The production in 1913, according to a Consular quotation from the Egyptian Gazette, was over 100,000 tons. About 90 per cent. of the output was shipped to Japan. No figures have been obtained for 1914. The Tunisian concern, the Societe des Phosphates de Gafsa, sent a representative to examine the Egyptian deposits with a view to acquiring the same. The results of the investigation show that, with the exception of the deposits in the Safaga district, the tonnage available along the coast of the Red Sea is very limited. The Gafsa company therefore gave up the idea of acquiring any property in this section.

Islands of the Pacific and Indian Oceans

The phosphate deposits which occur in several islands of the Pacific and Indian Oceans are of the highest grade yet discovered. Among the more important phosphate-producing islands of the Pacific are Ocean Island (English) of the Guilbert Group, Tahiti and Makatea (French) of the Society Group, and the Island of Naru (German) of the Marshall Group. Besides these, Christmas Island in the Indian Ocean contains a large tonnage of high-grade rock. The statistics showing the total production from these islands in 1913 and 1914 have not yet been published, but in 1912 the total exportations amounted to 600,000 tons. Christmas Island produced in 1913, 150,005 tons.

In 1914 the average price in England of the phosphates from these islands was 16 cts. per unit of P_2O_5.

Early in the war the German phosphate holdings were confiscated by the English. The government of New Zealand has applied to Great Britain for the privilege of exploiting these deposits. It is estimated that these islands have a reserve supply of phosphate amounting to 155 million tons.

Europe

Russia.—There are three main regions in Russia containing phosphate rock of commercial value. Named in the order of their present importance they are as follows:

The Southern region, in the governments of Podolia and Bessaribia, where the deposits are close to the Austrian frontier; the Northern region,

where the deposits occur in Jurassic and Cretaceous rocks in the governments of Viatka Vladimir, Kostrom, Ryazan, Sunbir and Yaroslavl; and the Central region of Cretaceous phosphates which are found in the governments of Voronezh, Kaluzh, Kursz, Orel, Saratoff, Smolensk, Tamboff and Chernigoff.

The Northern and Southern regions have been examined geologically and the latter exploited, but little is known of the Central region except that phosphate exists in considerable quantities.

The phosphates of the Southern region are mined chiefly by underground workings. The average grade of the rock is said to be 75 per cent. bone phosphate of lime. Much of the material is shipped to Poland and made into acid phosphate. The production of Russian phosphates for 1907–1913 is given in Table IX. Later statistics are not yet available. The average price delivered at the railway station was $9.30 per ton.

Fertilizers are imported to Russia in large quantities from Germany, Belgium and England.

TABLE IX.—PRODUCTION OF PHOSPHATE ROCK IN RUSSIA
(Metric tons)

Year.	Amount.	Value.
1907	11,290	$104,997
1908	14,786	137,510
1909	12,906	120,226
1910	15,293	142,225
1911	10,200	94,860
1912	25,000	.....
1913	25,000	.....

TABLE X.—IMPORTS OF FERTILIZERS TO RUSSIA

	1911, Poods.	1912, Poods.	1913, Poods.	1914, Poods.
Mineral Phosphorites	1,770,000	.....	3,800,000	1,239,512(a)
Other Nat. Fertilizers	353,000	.....	5,000,000	.....
Unground Thomas Slag	11,000	.....	.....	.....
Crude Ground Bones	11,000	.....	154,089	16,900(a)
Ground Thomas Slag	8,513,000	11,258,471	11,366,463	7,105,427(a)
Superphosphates	9,425,000	11,491,153	12,000,000	7,214,940(a)
Bones treated with H_2SO_4	21,000	.....	.....	.....
Roasted Bones	2,600	.....	.....	.....
Stassfurt Salts, German	4,155,000	.....	4,700,000	.....
Chloride of Potassium	177,000	.....	.....	.....
Chile Saltpeter	1,936,000	.....	1,000,000	.....

(a) Jan. to Oct., 1914.

A letter from Petrograd to the *American Fertilizer* early in 1915 states that the authorities have decided to erect public superphosphate factories in order that the country may be independent of other countries. Heretofore the nation has largely depended on fertilizer materials from other countries.

France and Belgium.—At one time the phosphates of these two countries were of considerable commercial importance, but their exporta-

tion in recent years has fallen off to a large extent, not only because of the depletion of the deposits, but because of the discovery of the higher grade rock in other parts of the world.

It is needless to say that mining in these two countries ceased during the latter part of 1914.

As importers of raw materials and manufacturers of soluble phosphates and basic slag, France and Belgium have been important countries in the phosphate industry. The imports and exports of phosphate rock for the past 4 years are given in Table XI.

TABLE XI.—FRENCH IMPORTS AND EXPORTS OF PHOSPHATE ROCK
(In metric tons.)

Year.	Imports.	Exports.
1911	740,356	.....
1912	903,489	22,062
1913	934,688	21,128
1914	(a)647,769	(a) 9,814

(a) 10 months.

In 1913 Belgium produced a little over 18,000 tons of phosphate rock, 1587 tons of which was shipped to the United States and used as a filler.

The exportation of basic slag from this country in 1913, however, amounted to 685,907 metric tons. This latter material averages about 17 per cent. of phosphoric acid and is ground so that 75 per cent. passes a 100-mesh sieve. It brings about 50 cts. per unit of phosphoric acid. The domestic consumption of basic slag is approximately 100,000 tons. The Belgian imports and exports of phosphate rock and basic slag are given in Tables XII and XIII.

TABLE XII.—BELGIAN IMPORTS AND EXPORTS OF PHOSPHATE ROCK
(In metric tons)

Year.	Imports.	Exports.
1912	244,221	22,916
1913	244,765	18,158
1914	(a)113,668	(a)10,988

(a) First 6 months of 1914.

TABLE XIII.—BELGIAN IMPORTS AND EXPORTS OF BASIC SLAG
(In metric tons)

Year.	Imports.	Exports.
1912	130,439	550,841
1913	144,553	685,907
1914	(a)76,248	(a)335,016

(a) First 6 months of 1914.

Germany.—With the exception of those contained on several insular possessions, Germany has no phosphate deposits of commercial value, and has therefore depended largely on her imports from other countries to supply her phosphatic fertilizers. The present blockade of German ports is what has affected the phosphate industry in Florida so seriously, since heretofore a large percentage of the rock exported from the Florida fields has been shipped to Germany. The demand for phosphatic manures in Germany, however, can be partly met by the large production of basic slag. Up to the present war much of this slag was shipped out of the country, but it is now conserved for domestic use.

The imports of phosphate to Germany for the past 4 years are given in Table XIV. The imports and exports of basic slag are given in Table XV.

TABLE XIV.—IMPORTS OF PHOSPHATE INTO GERMANY
(Metric tons)

Imported from	1911.	1912.	1913.	1914.
United States	378,770.4	342,646.3	421,212	420,163(a)
Algeria	164,691.9	190,747.9	107,405	
Tunis	62,267.1	115,206.1	108,707	
Belgium	91,265.9	63,011.0	53,433	
Christmas Islands	63,778.6	52,015.9	70,467	
Australia	20,804.3	49,248.1	18,866	
German Australasia	17,005.3	44,257.7	.....	
France	15,681.9	40,686.4	19,529	
Other countries	18,994.2	5,024.8	4,129	
Total	833,259.6	902,844.2	803,748	
Total value	$9,915,794.0	$10,743,796.0	$8,664,953	

(a) First 6 months of 1914.

TABLE XV.—GERMAN IMPORTS AND EXPORTS OF BASIC SLAG
(In metric tons)

Year.	Imports.	Exports.
1912	372,835	663,024
1913	441,069	713,878
1914	(a)234,081	(a)307,106

(a) First 6 months of 1914.

England.—Phosphate in the form of coprolites has been found in various parts of the British Isles, but not in sufficient quantities to prove of commercial importance.

This country, however, controls the rich deposits of phosphate on Ocean Island and has confiscated, since the war, several valuable phosphate deposits belonging to Germany.

England also has a large annual output of basic slag.

The imports and exports of fertilizer materials for the past 3 years are given in Tables XVI and XVII.

TABLE XVI.—IMPORTATIONS OF PHOSPHATE MATERIALS TO ENGLAND
(Metric tons)

Material.	1912.	1913.	1914.
	(a)	(a)	
Basic slag	41,883	43,403	16,838
Guano	11,723	17,285	39,915
Phosphate rock	462,414	486,989	564,521
Total	516,020	547,677	621,274

(a) First 11 months.

TABLE XVII.—EXPORTATIONS OF PHOSPHATIC MATERIALS FROM ENGLAND
(Metric tons, 11 months)

Material.	1912.	1913.	1914.
Superphosphate	(a) 82,514	(a) 61,416	67,111
Phosphate rock	4,492	11,808	2,646
Basic slag	(a)148,180	(a)157,207	134,808
Total	235,186	230,431	203,565

(a) First 11 months.

Spain.—The mining of phosphate rock in Spain has now practically ceased. In 1912, 3892 tons[1] of low-grade phosphate was produced, but no production has since been reported. The imports of phosphate-bearing substances for the past 3 years are given in Table XVIII.

TABLE XVIII.—IMPORTS TO SPAIN (a)
(In metric tons)

Material.	1912.	1913.	1914.
Phosphate rock	176,183	254,463	(b)163,921
Basic slag			
Superphosphate	161,047	149,602	(b) 97,571
Guano	2,486	1,781	(b) 2,382

(a) Figures obtained from Le Movement Int. des Engrais Chimiques, No. 3, ' Rome, 1915. (b) January to October.

SOUTH AMERICA

Peru.—The deposits of guano owned and controlled by this country have been important sources of nitrogen and phosphoric acid since 1842. These deposits have furnished many millions of tons for agricultural purposes, but with proper precautions for their conservation they can continue to supply a large annual tonnage almost indefinitely.

In 1890 the Peruvian Corporation, Ltd., an English company, was granted the right to take guano from Peruvian territory up to the amount of 3,000,000 tons (an allowance which was afterward reduced to

[1] Le Movement International des Engrais Chimiques, No. 2, Rome, Mar., 1915.

2,000,000 tons) and over 50 per cent. from the Lobos Islands. Since that time, up to April 1913, the corporation had exported 1,134,918 tons.

In the early part of 1915 the Peruvian Congress passed a law declaring a preferential right in favor of national agriculture, thus canceling the former agreements. The government has taken this stand because most of the guano is being shipped out of the country, to the serious detriment of the agricultural interests of the country. The Peruvian Corporation, Ltd., is making every effort to bring about a reversal of the law.

The local demand for Peruvian guano in recent years has been far greater than the amount supplied.

The consumption of guano in Peru (both high and low grades) for the past 5 years was as follows:

	Tons.		Tons.
1909–10	26,220	1912–13	36,592
1910–11	25,083	1913–14	38,787
1911–12	39,456		

The figures giving the total production and exports of Peruvian guano for 1914 are not yet available; the amounts produced and exported during 1912 and 1913 are given in Table XIX.

TABLE XIX.—PRODUCTION AND EXPORTATIONS OF PERUVIAN GUANO
(In metric tons)

	1912.	1913.
Production	72,305	74,337
Exportations	38,633	37,530

Chile.—According to a report published in the *American Fertilizer* in November, 1914, a rich phosphate deposit has been discovered in the valley of the Hausco River, 300 miles north of Valparaiso. The government engineers are examining the area and will issue a report on its economic importance.

ASIA

Japan.—Extensive explorations by the Japanese finally resulted in the discovery of deposits of phosphate rock on Rosa Island at the extreme end of the Loochoo Islands. The "Rosa Phosphate Co," a Japanese company, in an article[1] published several years ago stated that the phosphate on this island is nearly as rich as that from Christmas and Ocean Islands, averaging about 77 per cent. bone phosphate of lime and 2 per cent. combined oxides of iron and aluminium. The total amount of phosphate contained on the island is estimated at 2,800,000 tons. Some phosphate has also been mined in the province of Eclugo.

The production of phosphate in Japan amounted to 7879 tons in 1912,

[1] *Amer. Fert.*, Oct. 7, 1911.

about 8000 tons in 1913, and 28,022 tons in 1914. This quantity is far below that consumed in the Empire, the major part being imported from other sources. The amount of phosphate imported into Japan from January to September, 1914, from various sources is given in Table XX.

TABLE XX.—IMPORTS OF PHOSPHATE ROCK TO JAPAN

Country.	1911.	1912.	1913.	1914. (a)
England	5	.....	21,990	(b)
France	5,450	.....	.....	.....
United States	81,900	74,700	38,740	54,063
Egypt	.....	10,220	29,700	68,157
Other countries	141,000	198,000	238,150	144,702

(a) From January to September, 1614. (b) Included in figures for other countries.

China.—No production of phosphate has been reported from China, but it has been stated that deposits of phosphate occur on Pratas Islands, 170 miles south of Hong Kong. A Chinese company, the "Tony Sartou and Pratas Islands Phosphate Syndicate," has obtained concessions to work the deposits, which are estimated to contain 960,000 tons.

West Indies

Several islands in the Caribbean Sea (notably Curacao and Aruba) contain phosphate deposits of excellent quality. In October, 1913, mining was resumed on the Island of Curacao after a suspension of 20 years. A total of 1850 tons was produced from the island in 1913. No figures have yet been obtained for 1914. An English company was mining the rock, which is of exceptionally high grade, containing from 80 to 85 per cent. bone phosphate of lime and less than 1 per cent. of the combined oxides of iron and aluminium.

Technology

The production of soluble or available phosphoric acid from phosphate rock by means other than its treatment with sulphuric acid still continues to be a favorite problem for research chemists and engineers.

No method has yet proven so universally successful as the acid process, but where cheap power or other means for promoting chemical reactions are at hand, some of the processes proposed and patented may be economically practised.

Processes of Haff,[1] *Washburn,*[2] *and Hechenbleikner.*[3]—These processes are modifications of several previous schemes which are all based

[1] U. S. Patent No. 1084856 (1914.)
[2] U. S. Patent No. 1100639 (1914.)
[3] U. S. Patent No. 1112211 (1914.)

on the old method long in use for the manufacture of phosphorus. They consist in heating an intimate mixture of phosphate rock, coke and silica in an electric furnace to a temperature at which both the phosphorus and phosphoric anhydride are driven off. The volatilized products are then passed into a chamber where the phosphorus is oxidized, and the resulting product absorbed in water to form phosphoric acid which can be used to treat more phosphate in the production of double superphosphate or may be neutralized with ammonia gas forming ammonium phosphate, a compound of the highest fertilizer value. A plant near Charlotte, North Carolina, is actually producing this substance, and it is claimed that the P_2O_5 contained in the material can be produced as cheaply as by the acid process. It is needless to say that very cheap electric power is essential for the success of such processes.

Alcohol in the Manufacture of Phosphoric Acid and Phosphates.—In an article published in the *Journal of Industrial and Engineering Chemistry*, for June, 1914, P. J. Fox of the Bureau of Soils proposes the use of alcohol as a means of separating phosphoric acid from the gypsum and insoluble matter contained in acid phosphate. Two experiments in which acid phosphate was leached with alcohol of different strength showed that the extraction of phosphoric acid was quite complete.

After extraction the alcohol may be recovered by simple distillation.

Production and Fertilizer Value of Citric-soluble Phosphoric Acid and Potash.—The work described in this Bulletin is a continuation of that set forth in *Bulletin* 95 of the Bureau of Soils, U. S. Department of Agriculture. The author found that by mixing together phosphate rock and feldspar with addition of small quantities of iron and manganese to lower the melting point, a fluid slag was obtained at about 1400° C. which contained on cooling both phosphoric acid and potash in a citric-soluble condition. Experiments along these lines are now being conducted by one of the large steel companies with a view to obtaining slag of commercial value.

Ferro-phosphorus.—The manufacture of a material called ferro-phosphorus is being conducted at Rockdale, a few miles from Mt. Pleasant, Tennessee. The process is carried on in an ordinary blast furnace, but the charge consists of phosphate rock, sand, iron ore, and coke. The slag contains both phosphate and iron, but the latter is separated by a magnetic separator and recharged to the furnace. Ferro-phosphorus is used in the manufacture of special steels.

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PLATINUM AND ALLIED METALS

By J. F. Kemp

During 1914 platinum maintained the high prices which it has commanded in recent years. The maximum quotation by the *Engineering and Mining Journal* was $55–$60 per oz. on Aug. 15, shortly after the outbreak of the European war, and the minimum was $41–$42 on Dec. 26. In the early months of 1915, the metal has ruled $38–$40. The quotations which will be given below in full for 1914 make clear that shortly after hostilities were proclaimed the price temporarily rose, but later it declined and the average for the year was only 26 cts. above 1913. The paralysis of industry and the general hard times resulting from the war seem to have kept the price down, despite the suspension of exports for a time by the Russian government.

AVERAGE MONTHLY PRICES OF PLATINUM AT NEW YORK
(In dollars per troy ounce)

	1906.	1907.	1908.	1909.	1910.	1911.	1912.	1913.	1914.
January.....	20.50	38.00	25.50	24.10	29.00	39.06	46.00	45.50	43.38
February.....	25.00	38.00	25.50	24.00	28.75	39.31	45.63	45.50	43.50
March.....	25.00	37.00	25.50	23.75	29.13	41.00	45.50	45.50	43.50
April..... ...	25.00	32.50	23.50	23.50	29.25	41.35	45.50	45.50	43.50
May.....	25.00	29.50	22.50	23.25	29.55	42.81	45.50	45.50	43.50
June.....	25.40	26.20	23.50	22.75	31.38	42.88	45.50	45.50	43.50
July.....	26.00	26.75	20.00	22.43	33.00	42.95	45.50	45.50	43.50
August.....	26.00	28.13	18.75	22.65	33.00	44.38	45.50	44.90	50.20
September....	32.10	28.70	20.00	25.31	33.63	45.31	45.50	43.96	50.00
October.....	33.00	27.13	21.50	27.75	37.50	46.25	45.50	44.00	49.50
November....	35.50	26.31	24.00	29.50	39.44	46.13	45.50	43.70	45.45
December.....	38.00	26.00	24.00	29.50	38.75	46.00	45.50	43.45	42.19
Year.....	28.04	28.18	22.85	24.87	32.70	43.12	45.55	44.88	45.14

Much regret must be felt by all who use platinum for scientific or industrial purposes that the metal has found employment in jewelry. Either silver or gold is much better adapted to the production of attractive ornaments and is more beautiful than the grayish white of platinum, while of course neither has the high fusing point and resistance to acids which make platinum indispensable in science and the arts. The scientific and technical world needs all the platinum which can be obtained. No new source has appeared in 1914 comparable with the placers of the Urals, but one discovery has been made in Nevada which may appreciably increase the small American output, and much

interest has been attracted by the announcement of the presence of platinum in several sandstone beds in the district east of Cologne, Germany. Since these are of greatest interest they will be summarized before the older and better known sources are passed in review.

Nevada.—In September, 1914, the announcement was made that in a revived property in Clark County, southern Nevada, about 4 miles from the California line, discoveries of the platinum group of metals had been made under new and interesting relations. The mine is in the Yellow Pine mining district and is 10 miles west of Good Springs, which is connected by a narrow-gauge mine railway with the Clark railroad at Jean. As described by Fred A. Hale, Jr., in the citation given below, the veins is in a faulted or crushed zone which strikes N. 30 E. The country rocks are limestone and porphyry, but the ore appears in the limestone. The limestone strikes N. 60 W. and dips 10 to 20 to the south. The limestones are penetrated by intrusive masses determined as granite-porphyry by Adolf Knopf, of the U. S. Geological Survey, who gave a brief description of the vein at the Philadelphia meeting of the Geological Society of America in December, 1914. The nearest appearance of the intrusive to the ore is mentioned as 600 ft. by Mr. Knopf.

Mr. Seeley W. Mudd has given the fullest details available regarding the curious ore-bodies. In the fault zone, which is 20–30 ft. wide, the chief ore-shoot is a pipe which pitches to the northeast at the flat angle of 5–10°. It is slightly displaced by cross-faults. The interior core of the ore-shoot is light gray disintegrated quartz, in places changing to a black, vesicular, more blocky variety. Around the quartz is an irregular shell, from a few inches to 6 or 7 ft. in thickness, of hard and soft hematite with some limonite near the surface. Outside the hematite crust is a final shell of malachite varying from a thin seam to 20 in., but usually about 4 in. thick. With the interior quartz is a black or greenish-yellow talcy material which is said to be the richest ore. Of this some further details are given below. The light gray quartz is considered richer than the black compact variety, but the latter alone shows gold in the hand specimens. The hematite varies greatly in content of precious metals, but gold predominates. Its content of platinum and palladium is usually negligible. The malachite shell yields 20–30 per cent. copper. Oxidized copper and iron minerals stain the limestone near the ore-bodies, and the hematite shell runs into it in fingers and stringers. Additional detached lenses or shells of hematite have been found in several adits and when larger than 3 ft. in diam. they contain the disintegrated quartz.

While it is unusual to find hematite resulting from the oxidation of sulphides, in place of the normal brown iron ores, the appearance of this

anhydrous oxide is not unknown. Hematite as a vein material with quartz and copper ores is also unusual. One can not help suspecting that we are dealing with the alteration of a quartzose ore-shoot, originally formed of sulphides which on oxidizing amid severely arid conditions yielded the concentric shells.

The vein seems to have been opened for ore some 20 or 30 years ago and then to have been given up after unsuccessful attempts to extract the copper by leaching. After years of idleness, renewed exploration yielded assays for gold and the metals of the platinum group. As might be anticipated in so arid a region, the ores so far as opened are fully oxidized. A sample kindly sent the writer by Dr. F. J. H. Merrill of Los Angeles is a yellowish-green earthy mass, noticeably heavy and inclined to form soft lumps. Mr. Knopf describes the mineral containing the values as plumbo-jarosite, $Pb[Fe(OH)_2]_6(SO_4)_4$, which is a recently identified species varying from the natural potash iron alum, jarosite, in that it contains lead. One would infer a derivation from an original pyrite-galena combination or some such mineral as bournonite, which had oxidized in the presence of potash. In reporting the results of assay upon a rich sample, Ledoux & Co. express the opinion, as cited by Mr. Hale, that the precious metals are in the free state, "being apparently alloys of gold and platinum metals." Palladium was present with platinum, as is generally the experience where platinum is found in vein or lode deposits with copper. The ratios of the two vary much in the published results. Mr. Hale states that the ratio of gold to the platinum group is fairly fixed at 1:⅔. When panned down the gold is rusty and needs to be rubbed or treated with acid to show its yellow.

World-wide experience with platinum and its associated metals has shown that when in appreciable quantities they are usually associated with basic igneous rocks. The metallic platinum favors olivine rocks. But we are not without some reported associations with more siliceous ones. Thus, in the upper waters of the Tulameen River region in British Columbia the writer obtained tests for platinum in a sheared granite.[1] Platinum has also been detected in association with syenites.[2] It is known in several instances in veins,[3] and it enters in a subordinate way into the composition of rare varieties of tetrahedrite and bournonite, both antimonial sulphides of copper which in bournonite are combined with antimonial sulphide of lead. As far back as 1854, Mr. E. Gueymard announced the identification of platinum in tetrahedrite and bournonite in the metamorphic limestones of the French Alps, which are associated with the variety of granite or granite-gneiss formerly called protogine.[4]

[1] *Bull.* 193, U. S. Geol. Surv., p. 49, 1902.
[2] *Idem*, p. 8.
[3] *Idem*, p. 7.
[4] *Idem*, pp. 65–66.

An original platiniferous lead-copper mineral such as bournonite would be a not unlikely source of oxidized lead-bearing alums such as plumbojarosite with the platinum metals. In the silver ores of Gaudalcanal, Spain, described as resembling tetrahedrite, platinum was reported in 1806. The country rock is said to be a mica-schist.[1] More detailed investigation of the new discoveries in Nevada may add much of great interest to our scanty knowledge regarding platinum in other associations than the peridotites.

References on the Nevada discoveries:

ANON.—The Platinum Ores of the Boss. Salt Lake *Min. Review*, Oct. 30, 1914.

HALE, FRED A., JR.—Platinum Ore in Southern Nevada. *Eng. Min. Jour.*, Oct. 10, 1914.

KNOPF, ADOLF.—Abstract of a paper before the Geological Society of America, Dec. 1915. *Min. Sci. Press*, p. 990, Dec. 26, 1914.

MUDD, SEELEY W.—The Boss Mine, Good Springs, Nevada. *Min. Sci. Press*, p. 297, Feb. 20, 1915.

Germany.—Much interest has been felt for a year or more past in the announcement widely circulated that platinum had been discovered in the Lower Rhine region of Germany. Assays of sedimentary rocks—sufficient to raise hopes of commercial value—have been reported. Finally, the authoritative investigation of the reports was placed in the charge of Professor Paul Krusch, of the School of Mines in Berlin, one of the most esteemed and trusted mining geologists the world over. The area of interest lies in southern Westphalia, 20–30 miles east of Cologne. The platinum has been identified near the towns of Freudenberg, Siegen, Meschede in Siegerland, and in the districts of Sauerland and Westerwald. A series of fragmental sediments including slates and graywackes enters into the Silurian and Devonian systems. The graywacke seems to be most esteemed by the prospector. Professor Krusch describes it as a clastic rock made up of fragments of quartz and slate, cemented by argillaceous matter. Specimens which are sold by dealers in this country as representing the platinum-bearing rock, and which have been seen by the writer, are a light-colored clastic, apparently feldspathic rock, with narrow black streaks running through it, apparently along bedding planes. Professor Krusch mentions carbonaceous matter as sometimes appearing. The sediments are believed to be of marine origin. Since basal granite is known beneath the sediments, the inference is drawn that it has been the source of their components.

Microscopic study has shown small gold particles in the cement of the platinum-bearing rock. Minute black specks were also seen which could be distinguished from the coarser graphite scales and which, in the

[1] *Idem*, p. 81.

absence of any other mineral to which the platinum could be referred, were believed to be the source of it. Dr. Pufahl has determined the presence of chromium, platinum, radium, iron, and gold in the ore; and Dr. Hommel, chromium, nickel, arsenic, antimony, iron, copper, lead, zinc, silver, and gold. Some of these elements certainly argue a later introduction than during sedimentation, so that Professor Krusch classifies them into an older group, which might be of placer origin, embracing chromium, nickel, iron, platinum, iridium, silver, and gold, and a later group which might have been introduced into the sedimentary rock by solutions at a later date, viz., copper, lead, zinc, arsenic, antimony, and silver. The presence of chromium, nickel, platinum, and iridium leads one to suspect the presence in the original granitic landmass, which furnished the mass of the sediments, of some dikes or other forms of basic igneous rock.

Professor Krusch gathered samples of 2 kg. which were carefully sealed, and other lots of ten or twenty times as much in sacks. Assay samples were ground to 280 mesh to the inch and 200 to 300 gm., or 7 to 10 assay tons, were fused at once. In wet methods a kilogram was used. Even with the great fineness of the samples wide variation resulted in the determinations. The maximum is roughly an ounce to the ton (a Troy ounce is 31.1 gm. and a metric ton is almost the same as a long ton); the minimum, a trace. In the following tabulation six different laboratories worked in pairs on three different tests. The laboratories are given letters; *A* and *B* took one test; *C* and *D* another; *E* and *F* a third:

Laboratories	*A*	*B*	*C*	*D*	*E*	*F*
Grams per ton	30	tr.	33.5	3.8	8.0	0.8

Professor Krusch does not believe the platinum is in the colloid state, but interprets the varying results as due to the variable distribution of the metallic particles, even in portions of the same original sample. He concludes that only working on a large scale will be finally demonstrative of the commercial yield. The above abstract has been taken from a translation by F. Sommer Schmidt[1] of an address of Professor Krusch before the German Metallurgical and Mining Society and printed in *Metall und Erz.*

Previous to the publication of Professor Krusch's address, a company had been formed to treat the platinum-bearing sandstones, following investigations by Dr. W. Hommel of the Clausthal Mining Academy.

[1] *Min. Sci. Press*, Dec. 5, 1914, p. 879.

Dr. Hommel had exhibited a bar of platinum 500 gm. in weight, obtained from 1 ton of concentrates derived from 25 tons of crude ore.[1]

Platinum has been detected in ancient sedimentary beds in several places in the United States in former years. In 1852 Dr. F. A. Genth of Philadelphia reported it in a clay slate from Lancaster County, Pa., wherein it was associated with chalcopyrite and galena. Mr. Albert W. Johnston had found extremely variable amounts in a black Triassic shale east of Boyertown, Pa.

Assays have also been made by the last-named observer upon shales from the vicinity of Williams, Arizona, and from the clays in Cataract Canyon, a branch of the Grand Canyon of the Colorado.[4] The extreme variability in values, however, has deterred extended exploitation of the ancient placers.

United States.—The placers of Oregon and California have continued to yield the modest by-product of platinum which has characterized them in recent years. In 1914 the U. S. Geological Survey reported 570 crude oz. from which 525 oz. of metallic platinum was extracted. The Boss gold-copper-platinum mine, near Goodsprings, Clark County, Nev., produced 110 oz. of platinum. Besides the platinum obtained from sands and platinum ore 2,906 oz. of this metal was obtained from new material, of both domestic and foreign origin, by smelters and refiners of gold and copper bullion and mattes.

STATISTICS OF PLATINUM IN THE UNITED STATES

Year.	Production. (a)		Imports.			Total.
			Unmanufactured.		Manufactured.	
	Troy oz.	Value.	Troy oz.	Value.	Value.	Value.
1898	225	$ 3,375	101,018	$1,178,142	$ 52,283	$1,233,800
1899	300	1,800	187,778	1,462,157	55,753	1,539,710
1900	400	2,500	118,919	1,728,777	36,714	1,767,991
1901	1,408	27,526	85,438	1,673,713	24,482	1,725,721
1902	94	1,814	105,450	1,950,362	37,618	1,989,794
1903	110	2,080	114,521	1,921,772	135,889	2,059,741
1904	200	4,160	103,802	1,812,242	105,636	1,922,038
1905	318	5,320	104,196	1,985,107	188,156	2,178,583
1906	1,439	45,189	137,556	3,601,021	187,639	3,833,849
1907	357	10,589	74,208	2,509,926	175,651	2,696,166
1908	750	14,350	50,768	1,096,615	134,119	1,245,084
1909	638	15,950	118,851	2,557,574	410,997	2,984,521
1910	773	25,277	120,478	3,320,699	333,965	3,679,941
1911	940	40,890	122,390	4,722,752	135,842	4,899,484
1912	1,005	45,778	104,683	4,334,488	159,995	4,540,261
1913	1,484	.....	117,947	4,938,706	105,553	.....
1914	3,541	.....	72,267	2,934,580	39,143	.....

(a) Statistics of the U. S. Geol. Surv.

[1] *Min. Jour.*, p. 486, May 23, 1914; *Min. Sci. Press*, Jan. 31, 1914; p. 1001, June 20, 1914; *Metall u. Erz*, June 22, 1914.
[2] *Bull.* 193, U. S. Geol. Surv., p. 59.
[3] *Idem*, pp. 33 and 59.
[4] *Idem*, p. 51.

Russia.—MINERAL INDUSTRY for 1913 reviewed the conditions affecting platinum in the Urals for that year. Too late to be included, two valuable papers on the industry were published by Mr. E. de Hautpick, a Russian engineer, formerly a resident of New York and well known to many Americans in the metropolis. Mr. de Hautpick's papers appear in the *Mining Journal*, London, Sept. 20, 1913, and March 14, 1914, and are reprinted in the *Mineral Resources of the United States*, 1913, Part I, 451-454. In recent years explorations have been conducted in the endeavor to enlarge the productive areas. The investigations of Professor Louis Duparc, of the University of Geneva, Switzerland, have revealed new deposits farther north than the older ones worked, and like them, in the drainage areas of basic igneous rocks. Aside from the exploration of new territory, the most important step in maintaining the output is the introduction of dredges, built on the lines of those so successfully employed for gold in California. Lower grade gravels can thus be treated than are available by old-time hand labor. At least one, constructed in his country has been shipped to the Urals, but the outbreak of the European war has crippled for the time being further developments.

PRODUCTION OF PLATINUM IN RUSSIA

Year.	Official.	Actual.	Year.	Official.	Actual.	Year.	Official.	Actual. (a)
	oz.	oz.		oz.	oz.		oz.	oz.
1897.....	179,879	395,200	1903.....	192,976	226,000	1909.....	164,513	275,000
1898.....	193,213	203,100	1904.....	161,950	290,120	1910.....	176,334	300,000
1899.....	191,464	380,900	1905.....	167,950	200,450	1911.....	187,008	280,000
1900.....	163,060	212,500	1906.....	185,546	210,318	1912.....	177,596	300,000
1901.....	203,257	315,200	1907.....	172,064	310,000	1913.....	173,642	275,000
1902.....	197,024	380,806	1908.....	156,792	250,000	1914.....	156,775	240,000

PRODUCTION OF PLATINUM IN THE URALS
(In troy ounces)

District.	1908.	1909.	1910.	1911.	1912.
South Verchotur.....	97,747	100,986	111,070	121,317	118,231
North Verchotur.....	13,032	14,727	11,858	11,367	13,061
Perm.....	36,735	39,867	46,071	46,882	38,706
Tcherdinsk.....	7,452	7,161	6,361	(a)6,400	6,166
South Ekaterinburg.....	1,826	1,772	974	(b)1,042	(c)1,332
Total.....	156,792	164,513	176,334	187,008	177,596

(a) Estimated. (b) Includes 2 oz. from North Ekaterinburg. (c) 5 oz. from North Ekaterinburg.

Colombia.—Colombia continues after Russia to be the chief producer of platinum. As has been often stated, the metal is obtained as an associate of gold in the western central portion of the republic. The placers are at the head-waters of the San Juan River, which flows westward to the Pacific, and of the Atrato, which flows north to the Caribbean. Interest in these placers continues active. Conditions were described by

F. Lynwood Garrison in MINERAL INDUSTRY, **22**, 598 (1913). More recent developments are set forth in the *Commerce Reports* of the U. S. Consular Service, pp. 343–348, Jan. 25, 1915. Both English and American companies have been prospecting the San Juan River and its tributary, the Condoto, and are about to establish dredging on an extensive scale. The enlarged working of the lower grade or otherwise inaccessible gravels should add to the world's stock of platinum.

UNITED STATES IMPORTS OF PLATINUM FROM COLOMBIA
(In troy ounces)

Year. (a)	Quantity.	Value.
1909	2,392	$36,440
1910	1,600	31,383
1911	5,503	147,820
1912	6,627	219,128
1913	10,461	363,731
1914	12,387	398,657

(a) Fiscal year ending June 30.

British Columbia.—The platinum-bearing gravels along the Tulameen River are still objects of much interest, but as yet the development with dredges remains for the future. An excellent geological map and description by Charles Camsell is now available in Memoir 26 of the Geological Survey of Canada, 1913, on the Geology and Mineral Deposits of the Tulameen District, B. C. Observations of the writer in 1900 led to the conclusion that extensive production depends on the gold- and platinum-bearing grade of the gravels of the Tulameen above and below Otter Lake and below the mouth of Granite Creek. The amount of gravels appears to be sufficient, if the values should prove of remunerative grade. Mr. Camsell has summarized his conclusions on the source of the platinum in the *Mining Journal*, pp. 523–524, May 30, 1914.

Tasmania.—For 5 years past the creeks of an area of serpentine in northwestern Tasmania have been yielding an increasing amount of osmiridium. Beginning with 120 oz. in 1910, the output has been successively 271, in 1911; 778, in 1912, and 1263, in 1913, and 1248 in 1914. The Savage River and its small tributaries on the north side of a series of hills and a plateau of serpentine, and various other feeders of the Pieman River on the south side, furnish the productive gravels. The area of serpentine is called the Bare Hills, reminding one strongly of the same name for hills of serpentine near Baltimore, Md., and suggestive of the barren nature of soils from serpentine on whichever portion of the globe they appear. In Tasmania the depth of gravel varies from a few inches to several feet, but is shallow as gravels go. The scales and nuggets have often worked their way well down into crevices in the bed-

rock. They have also been traced to the parent ledge and have been detected in a sheared strip of the serpentine itself. Strangely no platinum has yet been found associated with the osmiridium.[1]

Armenia.—Platinum has been reported in the sands of the Charokh River in the district of Batum and Sasun. It is associated with gold.[2]

Congo Free State.—Platinum has been reported in the Katanga district in the southeastern Congo State. A section of auriferous sands is said to have yielded per metric ton: gold, 12.287 grains; platinum, 3.428; silver, 8.266.[3]

Physical Properties of Platinum

A paper on the "Total Emissivity of Platinum and the Relation between Total Emissivity and Resistivity," by Paul D. Foote, Scientific Paper No. 243, has been published by the Bureau of Standards, Washington, D. C., Jan. 30, 1915.

[1] E. J. Dunn, Tasmanian Osmiridium Fields. *Austral. Min. Stand.*, pp. 539–541, Dec. 24, 1914. W. H. Twelvetrees, *Bull.* 17, Geological Survey of Tasmania. Abstract in the *Min. Jour.*, Nov. 14, 1914.

[2] L. De Launay, in *Traite de Metallogenie*, 3, 758, pp. 744–759, gives a review of the distribution of platinum the world over.

[3] F. E. Studt, J. Cornet et H. Buttgenbach, Carte geologique du Katanga. *Annales du Musee du Congo*, Serie 2, Katanga, Brussels, p. 60, Feb., 1908.

POTASSIUM SALTS

By Samuel H. Dolbear

The extreme necessity of an American source of potash became more apparent than ever during the latter half of 1914, when the European war completely interrupted importations of potassium salts from Germany. In spite of this pressing need and the fact that at least one commercial source has been found, no production has yet resulted, and it seems likely that until European hostilities cease, consumers of potassium salts may have to abandon high potash fertilizers and other salts. It has been pointed out that, so far as fertilizers are concerned, the potassium is less essential than phosphorus and nitrogen, and that no great hardship may be suffered for 2 or 3 years.

The embargo placed upon the export of potash from Germany is based upon the theory that such potash might be used in the manufacture of explosives and eventually find its way into the hands of the enemy. The possibility of denaturalizing potash to render it impracticable for use in ammunition has been suggested, but no shipments of denaturalized product have yet been made. The reported modification of the embargo to permit the export of kainit has not become effective.

The extent of the interruption of importation in potassium salts may be appreciated when it is known that the United States imported during the fiscal year ending June 30, 1914, German potash salts for fertilizers aggregating 1,066,929 tons gross (equivalent to 256,920 tons K_2O). Importations for the 6 months, July 1 to December 31, 1914, amounted to only 182,192 tons, against 567,595 tons during the corresponding period of 1913, thus leaving a shortage on Jan. 1, 1915, of 383,403 tons.

The following table (p. 612) shows the imports of potassium salts of various kinds entered for consumption for the fiscal year.

The situation during the latter part of November, 1914, so far as the United States is concerned, is very fully described by the *American Fertilizer:*

"Conditions governing the potash situation have improved noticeably during the past 2 weeks. Muriate and sulphate of potash prices from second hands declined $6 to $8 per ton in the New York market. These salts have been in urgent request from chemical and pharmaceutical manufacturers since the war began, and many sales were made in excess of $100 per ton.

"The drop in values was due partially to the fact that potash salts in some form or other are arriving at various ports in a fair way. In addi-

IMPORTS OF POTASSIUM SALTS. (a)
(Tons of 2000 lb.)

	1910.		1911.		1912.		1913.		1914.	
	Quantity.	Value.	Quantity.	Value.	Quantity.	Value.	Quantity.	Value.	Quantity.	Value.
Bicarbonate	167	$ 16,633	163	$ 16,428	138	$ 13,155	156	$ 14,295	239	$22,767
Carbonate (crude)	4,204	263,643	5,340	327,400	3,299	207,417	5,032	295,066	4,523	240,451
Carbonate (refined)	4,518	303,917	5,572	395,728	5,313	383,958	7,018	412,587	5,211	368,858
Chloride	195,927	5,640,541	214,283	6,449,575	242,033	7,235,728	223,837	6,737,757	263,039	7,925,781
Chlorate	207	26,608	12	2,096	21	3,444	618	66,609	20	3,408
Chromate	439	43,037	11	1,699	22	2,273	14	2,601	17	2,822
Cyanide	1,211	328,146	1,163	326,973	1,048	312,777	475	137,535	618	183,259
Hydrate (crude)	4,392	358,855	3,713	309,965	4,211	330,684	4,497	348,500	4,283	336,650
Hydrate (refined)	72	11,095	41	9,254	39	8,096	56	11,919	9	1,977
Kainit	484,155	2,313,150	656,842	2,637,106	479,817	2,400,590	466,184	2,149,689	589,245	2,579,619
Nitrate (crude)	12,573	675,765	4,645	282,835	3,086	213,258	5,495	288,995	1,774	115,470
Nitrate (refined)	1,306	115,457	426	38,384	221	23,896	197	22,142	182	20,173
Prussiate (red)	33	12,460	27	10,230	35	11,264	33	11,30	45	15,325
Prussiate (yellow)	1,165	229,907	889	180,584	1,036	203,295	1,406	309,309	1,754	399,021
Sulphate	42,485	1,399,915	53,135	1,952,371	50,551	1,853,236	48,023	1,798,362	50,384	1,887,491

(a) For the fiscal years ending June 30.

tion, arrangements have been made for future shipments, and it is believed that the trade can depend on a certain amount of potash at regular intervals hereafter. The arrangement, of course, is to pay for the potash before it leaves Germany in American gold and make the ownership of it so certain that it will not be subject to seizure by war vessels of the belligerent nations.

"While it can not be truthfully stated that the entire trade has taken up this method of securing potash, yet sufficiently large quantities have been transferred to American ownership to make shipments total rather surprising figures, considering the difficulties encountered. Thus during September, 11,836 tons of kainit, 6737 tons of manure salts, 2863 tons of muriate of potash and 1080 tons of sulphate of potash arrived at all American ports.

"October shipments from Germany are reported to have reached a fair total, which, however, considering the amount actually needed here, is but a drop in the proverbial bucket. Naturally there is considerable secrecy prevailing in regard to arrangements made to ship from the other side, but no one now attempts to conceal the fact that considerable tonnage has been negotiated for and will undoubtedly be delivered to American consumers in due course.

"September imports of all potash salts exceeded 22,000 tons and it is reasonable to presume that, as time progresses, shipments will become more of a matter of fact, unless the nations at war should suspend traffic in this material. No embargos have been on potash exports from Germany for some time past, and the American State Department has expressed the opinion that American-owned goods in neutral bottoms are not subject to seizure."

This hopeful outlook has, of course, been dispelled by the later absolute embargo established by the German government, and if relief from this situation is to be had prior to the closing of the war, it will probably have to come from some new source of potash. Even were the embargo modified, as has been suggested, the problem of safe transportation would probably effectually prevent exportation.

The British government has forbidden the exportation of potassium and its salts, while the French authorities have held that potash is exportable. Supplies in each of these countries are very limited. During the latter part of the year, according to consular advices, sales were made in England at about $200 per ton. The advices failed to state what potassium compounds were sold at this figure, but it is assumed to be the chloride.

The turnover of the German Kali (Potash) Syndicate in 1914 amounted to approximately 156,000,000 marks ($37,128,000), a decrease in comparison with 1913, when the amount of 192,000,000 marks ($45,696,000) was recorded. In view of the fact that in July, 1914, an increase of 11,000,000 marks ($2,618,000) over other years was noted, an annual turnover of 210,000,000 marks ($49,980,000) would probably have resulted but for the war. Overhead charges in the operation of the works have risen considerably, to which fact should be added the increase in price of raw materials and the difficulty in obtaining proper help. The war has retarded the negotiations in regard to prolongation of the syndicate, and at a meeting in the near future steps will be taken in this direction.

The production of potassium salts in Germany in recent years is shown in the following official table:

PRODUCTION OF POTASSIUM SALTS IN GERMANY. (*a*)
(In metric tons and dollars; 1 mark = $0.238)

Year.	Kainit.		Potassium Salts other than Kainit.		Potassium Chloride.		Potassium Sulphate.		Potassium Magnesium Sulphate.	
	Quantity.	Value.	Quantity.	Value.	Quantity.	Value.	Quantity.	Value.	Quantity.	Value.
		$		$		$		$		$
1898	1,103,643	3,835,856	1,105,212	3,576,628	191,347	6,380,220	18,853	763,397	13,982	259,485
1899	1,108,159	3,838,250	1,384,972	4,202,000	207,506	6,801,250	26,103	1,027,500	9,765	195,000
1900	1,178,527	4,134,000	1,874,346	5,643,750	271,512	8,793,750	33,853	1,249,250	15,368	280,500
1901	1,500,748	4,327,250	2,036,326	5,443,250	282,750	8,782,250	27,304	1,460,000	15,612	286,500
1902	1,322,633	4,571,980	1,962,384	4,949,448	267,512	7,507,710	28,279	1,079,092	18,147	334,390
1903	1,557,243	5,208,154	2,073,720	4,993,478	280,248	8,125,320	36,674	1,389,444	23,631	441,252
1904	1,905,893	6,322,470	2,179,471	5,305,972	279,238	8,425,676	43,959	1,664,572	29,285	545,972
1905	2,387,643	7,976,808	2,655,845	6,396,250	373,177	10,580,528	47,994	1,804,040	34,222	614,754
1906	2,720,594	8,918,574	2,821,073	6,538,336	403,387	11,034,632	54,490	2,032,520	35,211	644,028
1907	2,624,412	8,579,206	3,124,955	7,314,930	473,138	12,639,704	60,292	2,216,494	33,368	631,652
1908	2,715,487	9,196,082	3,383,535	7,720,006	511,258	13,369,174	55,756	2,037,518	33,149	663,068
1909	3,181,349	10,646,792	3,860,685	8,787,198	624,994	16,245,642	68,539	2,574,684	38,722	697,816
1910	4,249,667	12,712,056	4,062,004	9,034,004	741,259	17,371,144	84,583	2,989,756	37,439	668,066
1911	4,425,497	13,757,452	5,181,379	11,794,328	838,420	19,851,342	107,631	3,967,460	42,253	780,974
1912	5,889,238	18,178,916	5,271,964	10,294,214	506,744	16,336,792	123,407	4,848,714	54,435	(*b*)
1913	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....

(*a*) From *Vierteljahrshefte zur Statistik des Deutschen Reichs.* (*b*) Value, $1,052,912.

Exports from Germany during 1912 and 1913 are given as follows:

Articles.	1912.		1913.	
	Metric Tons.	Value.	Metric Tons.	Value.
Carnallite with at least 9 per cent. and less than 12 per cent. K_2O.	6,853	$46,000	520	$3,000
Raw salts with 12 to 15 per cent. K_2O	853,117	4,094,000	1,124,816	6,697,000
Salts with more than 15 to 19.9 per cent. K_2O	35,530	286,000	49,687	404,000
Fertiliser salts, including potash fertiliser, with 38 per cent. K_2O.	373,685	5,510,000	460,865	7,855,000
Chloride of potash, not in shells or capsules	1,068	158,000	1,164	166,000
Sulphate of potash	85,749	3,660,000	133,358	5,700,000
Sulphate of potash-magnesia	48,600	1,085,000	59,207	1,339,000

The potash law restricts only production for exportation. Each mine owner is bound to contribute the whole of his portion of the domestic consumption and not more than his portion of the foreign consumption. If the total for both domestic and foreign has been underestimated, it is changed in the course of the year.

The distribution for 1915 has been provisionally placed at 562,100 metric tons K_2O for domestic and 386,700 metric tons for foreign consumption, but with shipments suspended as they are at present these figures have no practical value.

About one-half of the employees of the German Kali Works has been sent to the front as soldiers, and while authentic data regarding the extent of the syndicate operations in the Stassfurt fields are not available, it is assumed that a production of about 50 per cent. of normal is being maintained. It will be interesting to note in the expenditures of the Kali Works that those of its employees who are engaged in military duty are being paid their usual wages.

During the year the German Kali syndicate paid over to American potash consumers the $1,000,000 refund which was authorized last June by the Reichstag. This refund represented the return to American consumers of surtaxes paid under protest by American buyers during 1910 and 1911, during the operation of the German potash law, enacted in May, 1910, for the purpose of eliminating the favorable American contracts. This $1,000,000 had been paid by the German government to the syndicate at about the time the war broke out.

The syndicate has not paid over any actual cash, but is paying in potash. The potash with which it is paying has been advanced arbitrarily $4 per ton over the former contract prices, on the basis of the excuse that the war and the difficulties of shipping through neutral ports increase the cost $4 per ton. This is probably a true claim, but considering the fact that the Kali syndicate sells to American buyers at $27

per ton potash which actually costs only $8 per ton to produce, a profit of $19 or 240 per cent. per ton, the claim of needing this extra $4 is not calculated to stir any deep feeling of sympathy in the hearts of American purchasers.

The query is raised, why, if the Kali syndicate can ship this potash to pay its refund, it can not continue some regular shipments under its contracts, which it has notified the trade it has been obliged to rescind. The trade does not take this notice of abrogation of contracts by the syndicate at all seriously. After the war is over, if the syndicate attempts to do business with American potash buyers, it is likely to find some suits on its hands.

There are two factors in the European potash situation which are at present the source of a good deal of speculation. Alsace has become a producer, having shipped large amounts from the twelve or more mines being worked.

In Alsace, so far as at present known, the deposits of potash underlie an area of nearly 7 sq. miles. They range in thickness from 6 to 30 ft. and contain an estimated 1 billion cu. yd. or 1,472,058,000 tons of potash salts. On the basis of a 22 per cent. content of oxide of potassium, the total Alsatian deposit may be considered to hold 300 million tons of pure potash. It has recently been reported that the explorations in Baden, across the Rhine from the Alsatian potash mines, gave encouraging indications of the extension of the potash deposits into that district also. The future possession of Alsace is now in doubt, and should the administration pass out of German hands at the close of the war, potash from Alsace would possibly be sold in competition with the Kali Works.

Spanish Potash Deposits.—Although potash salts have been known to exist near the town of Cardona in the provinces of Barcelona and Lerida in Spain for several years, no production has yet been made. The European war is reported to have interfered with the plans for the development of these deposits which, under the most favorable circumstances, could not commence shipments before the latter part of 1915.

It is reported that efforts of the German syndicate to secure control of these fields have been partially successful, although some of the lands are in the hands of French interests. As it seemed likely that German control might result in closing down the mines, preparations are being made for the enactment of a law requiring continuous operation and production.

The situation in Spain is described by the American Consul General at Barcelona, in part, as follows:

"Up to the present, potash has not been extracted in Spain in commercial quantities. It has been proved, however, that potash does exist near Barcelona, that it is fairly amenable to refining, and that the deposits may become a basis of a world trade, with Barcelona as an export center. Examination and tests thus far have indicated only enough potash for consumption in Spain, but they have been so limited that it is impossible to estimate the quantity and grade of the deposits and the difficulties that may have to be undertaken in mining for this salt.

"It is presumed from the varied data gathered that the potash beds are extensive and rich and likely to have an important bearing on agriculture and certain highly important manufacturing industries, both in the Peninsula and abroad. What is now needed is a scientific and extensive survey of the regions in this part of Spain where marked traces of potassium salts have been found. For local consumption it is now probably possible to put certain quantities of potash on the market. As an article for export in regular and unfailing shipments, present indications do not point to a definite or even early conclusion.

"The tracts in Cataluna in which beds of potassium salts exist are chiefly in the two provinces of Barcelona and Lerida, particularly in the latter near the towns of Suria and Cardona on the Cardona River. At present, concessions do not go beyond Solsona on the north and the towns of Tarrega, Servera, and Manresa on the south, the entire district being practically confined between the Segre and Llobregat Rivers. In this region a number of these claims for mining concessions have been made on lands where there is no conclusive proof that potash exists in commercial quantities, although it is possible that these lands contain potash and that the potash-producing area may extend considerably beyond the confines mentioned. Thus far the prospecting has been satisfactory at and near Suria, but a thorough investigation must be made at Cardona and Callus, nearly midway between which Suria is situated."

Other Foreign Sources of Potash.—There have been few changes in the potash industry in other countries and conditions are substantially as outlined in MINERAL INDUSTRY for 1913. In Belgium and England limited amounts of potash are made from wool grease, and as by-products of sugar manufacture.

Italy has also entered the field as a producer of potash from beet-sugar refuse. Several hundred tons containing 47.20 per cent. K_2O have been shipped to the United States.

Niter deposits from India, Chile, and Africa furnish potash salts in relatively small amounts. The exports from Bengal are estimated at less than 10,000 tons per annum, while perhaps twice as much was

produced by workings in Chile. Of the various projects for making potash from phonalite, in Iceland, Italy and elsewhere, there is nothing new to report. In Scotland, Norway, and Japan potash and iodine are made from kelp, though in a relatively small way, and in Russia potash carbonate is made from the ashes of sunflower stalks. In Canada wood ashes from the big lumber mills is still an important source of supply for alkali works. It must be confessed, however, that outside of the United States, the possibility of successful competition with the Kali syndicate rests more and more on the chance of finding, by drilling, beds of salt similar to those worked at Stassfurt.

Potash in the United States

No important discoveries of possible sources of potash in the United States were made in 1914. At Searles Lake in San Bernardino County, California, the American Trona Co. has continued its work along experimental lines. The problem of commercially separating a soluble potassium salt from brine containing sodium chloride, sodium carbonate, sodium sulphate and other salines still remains unsolved.

Analyses of the Searles Lake brine from various wells drilled by the Trona Co. were given in Mineral Industry, **22,** p. 612.

The process worked out by John W. Horney, while successful experimentally, has been abandoned as non-commercial, and the plant unit designed to produce 5 tons of potash daily has been discarded. A firm of New York engineers which has also been engaged in this work for the American Trona Co. has devised a process which it is believed will successfully make this separation, but the details of this new process have not been made public. During the year, concrete buildings were built at Trona by the company and about 150 men have been employed in this and in the performance of assessment work on the company's claims. The litigation over titles to the claims still continues in a desultory way, but has not materially interfered with the company's operations. The American Trona Co., organized in 1913, was formed for the purpose of manufacturing for the California Trona Co., the latter company owning the claims.

The California Trona Co. has applied for patents on some of its claims at Searles Lake, and these applications have been protested by Victor Barndt of Tonopah, Nevada.

The bases of the protest are unusual by reason of the peculiar conditions resulting from the extended search for potash and the "locating" campaigns at Searles Lake. Mr. Barndt opposes the granting of the patent applications on the following grounds: (1) attempt to establish

monopoly; (2) failure of locators to make discovery; (3) that locations were not made in good faith.

At present, three applications are filed in the U. S. Land Office at Independence, Inyo County, Cal., by the California Trona Co. for patents to certain trona placer claims at Searles Lake. Each of these three applications Mr. Barndt regards as a test case intended to secure to the California Trona Co. title to substantially all of the known potash deposit at Searles Lake. He states:

"The first application is for six association placer claims of 160 acres each, located during July, 1910, by C. E. Dolbear and seven others. Against this application an adverse has been filed by contesting claimants, and the matter is now in the California courts.

"The second application is for one association placer claim of 160 acres located in July, 1910, by C. E. Dolbear and seven associates. No adverse claim covers any portion of this ground. The claims located by C. E. Dolbear and the same seven associates during July, 1910, comprise 257 association claims of 160 acres each, covering a total of more than 41,000 acres. All were conveyed to the California Trona Co. immediately after location.

"The third application is for four placer claims of 20 acres each, located in May or June, 1912, by S. W. Austin, being a portion of 1392, more or less, 20-acre claims located by Austin during May and June, 1912, and by him conveyed to the California Trona Co. on Nov. 12, 1912. No adverse claim covers any portion of this particular 80 acres.

"The Austin locations are on lands embraced within the Dolbear locations, and include the entire known commercial deposit of potash, borax and soda at Searles Lake, excepting the small percentage embraced in lands patented to the San Bernardino Borax Mining Co."

Mr. Barndt, in his protest against the proposed monopoly of Searles Lake, suggests that this could be obviated by the establishment of a Federal leasing system, such as that now before Congress, and that the California Trona Co. should be given the first choice of such leases as a recognition of its important and useful work in developing this deposit. Mr. Barndt is president of the Railroad Valley Co., which spent over $100,000 in prospecting for potash in Railroad Valley, Nevada, and other places in the West. He says that a large amount of money and effort has been expended by various private parties and by the Federal government in the search for commercial sources of potash; Searles Lake is the only known commercial deposit of potash in the United States and is likely to remain so. To allow one party to obtain patent upon substantially all of this deposit would, he thinks, establish a dangerous

monopoly in a necessary commodity. In protesting the patent on this ground, he says:

"If the present applications are allowed and patent is granted to the lands now applied for, the California Trona Co. by making additional separate applications for patent could ultimately control substantially all of the potash deposit at Searles Lake, and thereby control and monopolize the future potash industry of the United States."

Anent "failure to make discovery," preceding location of the claims, Mr. Barndt says:

"With the possible exception of a few bordering claims not of great value, no discovery of potash, borax or soda was made by C. E. Dolbear and his seven associates upon any of the 257 association claims when the locations were made in July, 1910, or prior to Aug. 11, 1910, when the locations were transferred to the California Trona Co. Between Aug. 11, 1910, and the Federal withdrawal of these lands on Feb. 21, 1913, discovery was made upon a portion of these claims. But even the claims upon which discovery was made after transfer are invalid and void except as to 20 acres each, and no selection or segregation of 20 acres out of any of the said association claims has been indicated.

"Upon the great majority (probably nearly 90 per cent.) of the Austin locations, no actual discovery of mineral other than common salt had been made at the date of the Federal withdrawal of these lands, Feb. 21, 1913. Upon the majority of these claims, no discovery has been made, even at this date. A discovery after the Federal withdrawal does not validate a location. The finding of common salt or of non-commercial traces of other minerals does not constitute discovery in this case."

Regarding Dolbear's locations, the protest states:

"The records indicate that Dolbear and seven associates, each of whom at that time was a stockholder of the California Trona Co., were, in making the locations in 1910, not locators in good faith as they pretended to be, but were dummy entrymen who located solely in the interest and on the behalf of the California Trona Co. I submit that these locations are therefore fraudulent and void."

Through supplementary statements of Mr. Barndt's attorneys, it is presented that in each of the three layers or series of locations with which Searles Lake is plastered, most, if not all, of the claims are void or voidable on grounds of non-discovery or of dummy entries. It appears that the California Trona Co. has not applied for patent under any of the 1908 Dolbear locations, but, as already noted, has filed two applications on certain 1910 Dolbear locations and a third application on 80 acres located by Austin, on which there were no adverse claims.

During the year the U. S. Geological Survey has issued a bulletin, prepared by Hoyt S. Gale, entitled "Salines in the Owens, Searles and Panamint Basins, Southeastern California." This is a very valuable addition to literature already available on the subject and discusses the origin of potash at Searles and other lakes and its possible economic importance.

Efforts to produce potash have also been directed along these other lines: (1) from "vinasse" or refuse from a distillery in California; (2) from California kelp; and (3) from siliceous rocks in which potash occurs as an insoluble compound.

The Pacific Chemical Co. commenced construction of a plant at Agnew, California, on a site adjacent to the distillery of the Western Grain & Sugar Products Co., and plans to utilize the refuse "vinasse" of the latter concern. No production has yet resulted.

At Point Loma, San Diego County, California, the Kelp Products Co. has built an experimental plant to extract potash from kelp, and a larger unit to dry the plants for use as fertilizer. Under the process which the company has patented the plants are chopped very fine, a deglutinizing agent being fed into the chopper. The juices are pressed from the kelp and the residual pulp dried. The juices are then evaporated artificially and the salts allowed to crystallize. The kelp is harvested with a mowing device which extends 6 ft. below the surface and is carried by a conveyor onto the barge. This is towed ashore and the plants are placed on a conveyor which carries them to a chopper which has been placed on the company's dock. From the chopper discharge the material is moved by another conveyor to a rotary tubular calciner in which a sufficient heat is maintained to thoroughly dry the kelp. The dried material is then ground and sacked. This equipment, which is already complete, is expected to produce kelp fertilizer commercially, and the owners expect to make shipments in May or June, 1915. According to officials of the company, the finished product has an analysis of 15 per cent. K_2O, 2 per cent. N, and 0.5 per cent. P_2O_5. This company is evidently the only concern as yet to make any serious attempt to produce kelp fertilizers in the United States.

The College of Agriculture of the University of California, which has investigated the Pacific Coast kelps, has recently published a bulletin by John S. Burd, entitled "The Economic Value of Pacific Coast Kelps." The publication discusses the chemistry of kelps and furnishes tables of analyses of kelps which may prove valuable for their chemical content.

The possibility of recovering potash from feldspar and feldspathic rocks has been given very careful study by Messrs. Allerton S. Cushman

ınd George W. Coggeshall. Their process has been described at length n *Metallurgical and Chemical Engineering.* (November, 1912, and ?ebruary, 1915). Early efforts along this line were confined to render- ng soluble the potash content of feldspar, and several hundred tons was ›roduced under normal working conditions. No attempt was made, ıowever, to separate and concentrate the potash salts. The finished ›roduct contained about 4.5 per cent. water, soluble potash (K_2O) in :he form of 7.1 per cent. muriate of potash (KCl). The experiments :arried on in a large way have led these engineers to the conclusion that ›otash may be successfully extracted from feldspathic rocks.

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PRECIOUS STONES

By George F. Kunz

The 7 months of the year 1914 until the declaration of war showed condition that seemed favorable to improvement in the precious-tone industry. Then the stagnation resulting from the war com-letely changed the whole aspect of affairs in a very short space of time. 'his was mainly due to the almost entire cessation of any demand from he European countries, as well as to a much modified consumption on he part of the United States. The demoralization reached its height ith the fall of Antwerp and the complete cessation of the diamond-utting industry there, which before the war equalled if not slightly xceeded in volume that of the mother of this industry, Amsterdam. 'hen the fact that many of those engaged in the commerce of precious tones in England and France were of German or Austrian origin, or ad names that indicated their race, caused the closing of their places, he proprietors being compelled to flee or be interned in the respective ountries in which they had lived. By a strange coincidence, many of he Hebrews left for Portugal where the diamond-cutting industry of the arly eighteenth century was so prosperous, and whence they had been lriven to Holland through religious persecution.

Secondly, the calling to the colors of a considerable number of men n the profession by the countries at war, has of course seriously hampered nany establishments, making it impossible to carry on business as it vas formerly done. Moreover, in Germany, there was the difficulty of hipping goods to the outer world from Oldenburg, Hanau, and other places, as well as from the Bohemian region where the cutting of gem tones has flourished. Even when shipments were made by way of Holland, or by way of Sweden, this meant delays, additional expense, isks, and interferences with a well-organized commerce.

In spite of these many drawbacks, however, the demand for the better class of stones is still sufficient to maintain prices, a result due in some degree, of course, to the diminished output. The diamond in its finer qualities is receiving more appreciation than ever. Sapphires may be said to be enjoying royal favor, and fine emeralds are quite as much in vogue as ever before. There has been an increased working of the American gem mines in Montana, and hence the production of American gem stones has been quite as great as in any previous year. The in-

trinsic value of pearls has been demonstrated by the maintenance of their value even at a time when almost the entire world had declared a moratorium. Here the notable falling off in the supply from some of the principal fisheries has for some time past operated to keep prices at a high level.

Among the more recent designs for bringing out the beauty and effectiveness of precious stones may be noted the use of a tint of black along the edges of the stone; for instance, a tiny mortised or mitered edging to the center of diamonds, or other gems, this onyx effect being used very successfully in many cases.

Rock crystal engraved and encrusted with a delicate tracery in some dull color, or surrounded by small diamonds in attractive grouping and setting has been used to a great extent.

The prevailing favor accorded to block tints for costume and accessories by the feminine world, in the autumn and winter seasons at least, may be assumed to have some connection with the prevalence of mourning in Europe, for woman's invincible tendency to emphasize the element of daintiness and beauty wherever possible has been displayed in the more graceful and even artistic and stylish effects recently given to mourning garments, in marked contrast to the more severe and even unlovely fashions of former days.

A novel form of diamond bordering for emeralds, rubies, or sapphires, consists of the adjustment at the sides of a square-cut colored stone, of four narrow, oblong, table-cut diamonds, each one of these extending along one of the sides of the central colored stone. The contrasting effect is very striking and beautiful, as the diamond material is in much closer and more intimate contact with that of the central stone than is the case where the latter is surrounded by a cluster of small faceted diamonds.

A special feature of this report will be a study of the diamond-mining industry in South Africa and elsewhere, embracing many valuable data on the organization of the numerous diamond-mining companies.

Markets and Imports.—The following official figures giving the total imports of precious stones for the years ending June 30, 1911–1914, show the falling off in the year 1914, before the European war affected the market, due to the higher tariff rates, which became operative after October 3, 1913.

While there was a slowing up during the first 7 months of the year, the decisive effect of the war is shown by comparing the total for the first 6 months with that for the last 6 months, the figures being, respectively, $13,558,722 and $6,206,265, of which latter amount $2,160,161 represents imports for the month of July before the beginning of hostilities.

	1911.	1912.	1913.	1914.
Diamonds, uncut, including miners', glaziers', and engravers', not set. Free.	$9,280,943	$9,833,513	$12,339,553	$4,956,014(a)
Diamonds, uncut. Dut.	.....	.....	.....	3,151,633
Diamonds, cut but not set. Dut.	24,407,295	24,537,150	27,213,047	17,795,099
Pearls and parts of, not strung or set. Dut.	1,140,293	2,089,313	5,806,673	4,263,933
Other precious stones, uncut. Free.	182,010	112,558	79,158	23,085(b)
Other precious stones, uncut. Dut.	.....	.....	.....	14,660
Other precious and semi-precious stones, cut but not set. Dut.	5,622,596	3,544,180	2,771,950	2,565,819
Imitation precious stones. Dut.	.....	1,181,045	1,319,464	1,192,897
Totals	$40,633,137	$41,297,759	$49,529,845	$33,963,140

(a) Including diamonds uncut from July 1 to Oct. 3, 1913, inclusive. (b) From July 1 to Oct. 3 1913, inclusive.

For the calendar years 1911–1914 the following figures of precious-stone imports are reported:

	1911.	1912.	1913.	1914.
Diamonds, uncut. Free.	$9,854,152	$9,863,770	$11,616,286	.....
Diamonds, cut. Dut.	.....	.....	956,576	$2,976,227
Diamonds, cut but not set. Dut.	25,705,563	22,876,042	24,886,133	12,022,146
Pearls and parts of, not strung or set. Dut.	1,387,689	5,139,406	5,004,489	2,142,221
Other precious stones, uncut. Free.	109,241	115,812	47,716	.....
Other precious stones, uncut. Dut.	.....	.....	9,459	32,596
Other precious and semi-precious stones, cut, but not set. Dut.	4,519,963	3,342,219	2,740,804	1,630,715
Imitation precious stones. Dut.	587,256	1,215,471	1,299,145	961,082
Totals	$42,163,864	$42,552,720	$46,560,608	$19,764,987

Thus in the first 7 months of the year (Jan.–July, inclusive), when trade in precious stones is least active, the average monthly imports were $2,245,550, while in the last 5 months (Aug.–Dec.), during which period the largest importations are usually made, the monthly average had fallen to $809,221, not 40 per cent. of that of the former months, and probably part of this represented the filling of orders given prior to the declaration of war.

The fact that the value of the imports for February, 1915, was nearly $2,000,000 ($1,884,903)—almost double the figures for the previous month, $1,035,917—shows the strong tendency to recovery even in the midst of the war, and gives us an indication of the rapid increase sure to follow the conclusion of peace.

The special degree in which the diamond trade of Amsterdam has suffered since the beginning of the war is clearly brought out in the comparative figures of exports from Amsterdam to the United States in 1913 and 1914. While the totals of all exports show a falling off of $2,367,542 in the last-named year as compared with the previous one, the decrease in diamond exports alone largely exceeded this, being

$5,465,484. The respective figures for 1913 and 1914 as invoiced at the United States consulate are as follows:[1]

	1913.	1914.
Cut	$10,085,701	$5,157,838
Uncut	985,161	447,540
	$11,070,862	$5,605,378

The immediate effects of the war are more strikingly shown in the following statement, giving the exports to the United States for the first 7 months and the last 5 months of the 2 years respectively, the heavy exports in the early part of 1913 being, of course, largely due to the impending increase in tariff rates.

	1913.		1914.	
	Jan.–July.	Aug.–Dec.	Jan.–July.	Aug.–Dec.
Uncut diamonds	$728,057	$257,104	$278,833	$168,707
Cut diamonds	7,900,426	2,185,275	4,497,216	660,632
	$8,628,483	$2,442,379	$4,776,049	$829,339

Although the exports for the closing 5 months of 1914, covering the war-period of that year, show a decrease of two-thirds in the value of cut and uncut diamonds sent from the port of Amsterdam to the United States, the stagnant condition of the local diamond industry might have led us to expect an even greater falling off; however, the still considerable amount of diamond material exported during this time is stated to have been partly due to a supply brought in by fugitive diamond dealers from Antwerp, who were forced to sell some of their stock at greatly reduced prices.

The disorganization of the diamond-cutting industry in Amsterdam as far back as the early part of 1914 appears from the fact that out of 9800 members of the Amalgamated Union of Dutch diamond workers, more than 50 per cent., or over 5000, were out of work at that time, the average number of unemployed workers never falling below 4000 during the ante-bellum part of the year. This important beneficial organization embraces almost all of the Dutch diamond workers. At the beginning of the war the proportion of unemployed rose to 80 per cent., the remainder only having employment for a part of their time.

A little has already been done to revive the diamond-cutting industry in Antwerp. At the outbreak of the war the German and Austrian

[1] See Consul D. I. Murphy's report of April 10, in Supplement to Commerce Reports, June 11, 1915, No. 9a, pp. 3, 4–6.

diamond dealers were practically driven from the city, but many of them returned after the German occupation. The German civil authorities in Antwerp have accorded some special privileges to the proprietors of diamond-cutting works with the result that this industry has been resumed to a limited extent. Of course wages have been greatly reduced. Where a wage of 75 francs was paid weekly the same worker has to be content with a weekly stipend of 28 francs. The demand is confined principally to the smaller stones, such as the half-carat diamond, locally called demi-gris, for which there is still a fairly good market in Germany, Austria, Italy and the United States.

In London, Hatton Garden, long known as a center of diamond interest, shows considerable activity, principally due to the presence here of many expatriated Belgian diamond cutters. From Amsterdam the report comes that in March of this year (1915) about 2000 cutters were able to find employment, while some of the small number of Belgian workers in this industry who are still able to find something to do are employed by a few manufacturers in Schevenningen, Holland, who have temporarily set up some small establishments there. They have already combined in a trade association and have subscribed funds for the constitution of a local Diamond Exchange.[1] Although these efforts are necessarily on a small scale, still they testify to the vitality of the industry and serve to show that as soon as the pressure of hostile influences shall have been removed, the diamond industry will be ready to reassume its important place in the industrial life of Antwerp.

An import duty is soon to be imposed in Canada on loose diamonds, which have heretofore been imported free. This duty is adjusted so as to favor English exporters, who have to pay only 5 per cent. of the value of the stones, while diamonds from Amsterdam or other non-British ports are dutiable at 7.5 per cent.

Diamonds[2]

Africa.—In reviewing the state of diamond mining in 1914–1915, it seems that the following list would be of interest, as it gives full data regarding the present condition of the mines:

African Diamond Development Co., Ltd., registered July 23, 1913, to acquire options on the Franzport mine near Pretoria and the Spytfontein mine near Kimberley. Capital, £125,000 in 500,000 shares of 5s. each, a few of which have been already issued.

Blaauwboschfontein Diamond Co., Ltd., registered November 18,

[1] See *Jeweller and Metalworker*, March 15, 1915, p. 278.

[2] Much of the data for this section has been obtained from Walter R. Skinner's "Mining Manual and Year Book for 1915;" (29th year of publication), London [1915] 968 pp.

1908, in the Orange Free State as the Blaauwbosch Diamond and Development Syndicate, Ltd.; name changed April, 1910. Owns freehold of 100 morgen (211 acres) on the Blaauwboschfontein farm, leasing the government's four-tenths of the mineral rights. Capital, £24,500 in fully paid shares of £1 each. Dividends, 1911–12, 7.5 per cent.; 1912–13, 67.5 per cent.; 1913–14, 60 per cent. *Quotations.*—1913, high 6⅛, low 3¾; 1914, high 5 1/16, low 3; latest 3–3½.

Consolidated Co., Bultfontein Mine, Ltd., registered in Kimberley, in January, 1888, to take over the properties of the Adamant Diamond Mining Co., Ltd., and the French and Esterre Diamond Mining Co., Bultfontein Mine, Ltd. At present the property, which has been leased in perpetuity to the De Beers Consolidated Mines, Ltd., since July 1, 1889, covers 430 claims in the Bultfontein Diamond Mine, Kimberley, Cape Colony. Capital, £721,500 in fully paid shares of £1 each. The rental paid by the De Beers company is equivalent to an annual dividend of 7.5 per cent. on the capital. *Quotations.*—1911, high 1½, low 1¼; 1912, high 1½, low 1 5/16; 1913, high 28s. 6d., low 26s. 1½d.; 1914, high 1 7/16, low 1 3/16; latest 1⅛–1¼.

Crown Diamond Mining and Exploration Co., Ltd., registered in the Orange Free State, November 13, 1908. This company acquired the two freehold farms of the Lace Diamond Mining Co., Ltd.; Driekop No. 630, with an area of 956 morgen, 500 square roods, and Ruby No. 961, area 1378 morgen, 218 square roods, or about 2018 and 2908 acres, respectively. The consideration was £75,000 in fully paid shares. For the 10 months from August 1, 1913 to June 1, 1914 the diamond yield was 21,536 carats from 219,002 loads washed, an average of about 1/10 carat per load. There was a net loss of £16,222 on operations for the 18 months ended December 31, 1913. Capital, £125,000 in £1 shares.

De Beers Consolidated Mines, Ltd., registered in Cape Colony, March 13, 1888, with a nominal capital of £100,000, to consolidate the diamond mining properties and interests of the De Beers and Kimberley mines, Griqualand West, Cape Colony. Control of the Koffyfontein Mines, Ltd., was obtained in 1911. One of the important successive stages of the development of this great company was the leasing in perpetuity of the Dutoitspan Diamond Mine (519 claims) in August, 1899, from the Griqualand West Diamond Mining Co., the annual rental being equivalent to a 4 per cent. dividend on the capital stock of this company; its debenture indebtedness of £158,000 was also assumed and has since been paid off. The 291 claims in the Bultfontein mine owned by the Consolidated Co., Bultfontein Mine, Ltd., were leased in perpetuity in September, 1899, for 7.5 per cent. on the capital stock of the original

company, and in November, 1889, the entire property of the Bultfontein Mining Co., Ltd., was bought for £745,454 of De Beers Bultfontein Obligations. The remaining large mine of the De Beers company, the Wesselton mine, was purchased from the Wesselton Estate in December, 1891, for £300,000; in 1900 the company acquired the property of the New Bultfontein Mining Co., Ltd., the total expense of this transaction amounting to £197,862.

At various times other important interests have been acquired by the De Beers company, such as those of the Compagnie Générale with holdings in the Brazilian Canivieras Mines; the Sultan Diamond Mining Co.; the United Diamond Mining Co.; the Spes Bona Bultfontein Diamond Mining Co.; the South African Diamond Mining Co.; the New Gordon Diamond Co., Ltd., and the British United Diamond Mining Co. For the Anglo-African Diamond Co. the sum of £677,500 in De Beers debentures was paid. The latest transaction of this kind has been the acquisition of the Voorspoed Diamond Mining Co., Ltd., the price paid being 12s. 6d. for each share of the Voorspoed, the De Beers company also assuming liability for a loan of £120,000; the cash payment for the shares totaled £253,271. The removal of a troublesome competitor, rather than the earning power of this mining property, was the determining factor with the managers of the De Beers company.

The capital of this great company is now £4,500,000, represented by 800,000 preferred shares and 1,000,000 common shares, each of £2 10s. par value. A cumulative dividend of 40 per cent. is assured to the holders of preferred stock before any dividend can be distributed on the common stock, which is then entitled to the whole remaining dividend distribution. The outstanding debentures of the company bearing interest at 4½ per cent., amount to £1,635,495. At the outset the capital of £3,950,000 was divided into 790,000 shares of £5 each, the present form of capitalization dating from December 1901, when each holder of a £5 share received in exchange one share of preferred, and one of common stock, the balance of the new stock issued being applied as bonus, and extinguishing the right of life-governors to a share of the profits. The dividend of 40 per cent. on the preferred was paid up to June, 1914, and the following annual distributions have been made in the common stock from 1903:

1903	55 per cent.	1909	20 per cent.
1904	55 per cent.	1910	40 per cent.
1905	40 per cent.	1911	40 per cent.
1906	40 per cent.	1912	60 per cent.
1907	70 per cent.	1913	60 per cent.
1908	No dividend.	1914	20 per cent.

For the current year (1915) the results will certainly be no better than in the year 1908, as of course all mining operations have been suspended. How long it will take to restore things to their former state no one can tell;

in any case the company's record so far speaks for itself, and the future will deal as kindly with it as with other legitimate and well-managed business ventures. The dividends on common stock for the past 12 years, as given above, show average annual dividends of 41⅔ per cent., certainly a most satisfactory result. *Quotations.*—1911, preferred, high 18½, low 17$^{15}/_{32}$, common, high 19$^{9}/_{16}$, low 17¼; 1912, preferred, high 18⅜, low 16⅜, common, high 22$^{23}/_{32}$, low 18½; 1913, preferred, high 17½, low 15$^{13}/_{16}$, common, high 22$^{1}/_{16}$, low 17$^{5}/_{32}$; 1914, preferred, high 17, low 12½, common, high 19¾, low 10¼; latest, preferred 12⅛, common 10¼. This is equivalent to 485 for the preferred and 410 for the common.

Although the Twenty-sixth Annual Report of the De Beers Consolidated Mines for the year ending June 30, 1914, just escaped the paralyzing effects of the world war, it nevertheless reflects a certain falling off in the demand for diamonds as compared with the previous year, one of exceptional prosperity. In that period the amount realized on diamond sales, added to the increased value of diamonds in stock, at cost of production, amounted to £6,297,782, while for the year 1913–1914 the corresponding figures are but £5,446,954. The amount actually realized on sales was £5,123,336; adding to this for sundry receipts from interest and dividends on investments, etc., £228,770, and £497,874 for previous balance, a total of £5,849,980 was attained. Mining expenses for the year were £1,992,628, other expenditures, taxes and depreciation charges, £984,516, and £51,253 was transferred to credit of General Fund, and dividends amounting to £2,050,000 were paid, making in all, £5,078,397, leaving the sum of £771,583, composed of £323,719 added production value of diamonds in stock, and £447,864, balance carried to Balance Sheet.

The diminished revenue did not justify as large dividends on the deferred shares as had been paid in 1913, when the amount of £1,750,000, or 35 per cent., was distributed among these shareholders in dividends and bonus; for the year 1914 the dividends so paid amounted to £1,250,000, or 20 shillings per share. The holders of preference shares received £800,000, as in the previous year.

In the pursuit of their consistent efforts to preserve the stability of the diamond market, the De Beers company was of course a most important factor in the attainment of an agreement among the leading diamond producers at the conference held in London in July, 1914, at which a satisfactory arrangement was attained, soon, however, to be rendered futile by the breaking out of the war. As a result of the negotiations, the De Beers company, through the Diamond Syndicate, acquired diamonds from the German deposits to the value of nearly

£273,000. At the annual meeting held December 29, 1914, Chairman Oats, in announcing this fact, remarked that at the time they had no anticipation that war was about to ensue, to which a shareholder remarked "I am afraid the Germans had."

When the decision was arrived at, early in August, to close down the mines, the company used every endeavor to provide for the necessities of its 2740 European employes, either furnishing them with transportation to some other locality where they could find work, or retaining them in the employ of the company at half-pay for a number of months. In the case of upward of one thousand of the employes, who volunteered for military service, the De Beers company engaged to make good to each one the difference between his pay and one-half of his previous salary. This entails a monthly expenditure of £7000 and may be regarded as not merely a benefaction to the employes, but also in some degree as a free-will offering in aid of the government.

The following table gives the figures representing the average yields of the different mines, the value of the diamonds per carat and the average value per load:

	1912.	1913.	1914.
Wesselton Mine.			
Average yield in carats per load	0.29	0.27	0.28
Value per carat	45s. 3.12d.	51s. 2.83d.	45s. 7.62d.
Value per load	13s. 1.504d.	13s. 10.02d.	12s. 9.33d.
Bultfontein Mine.			
Average yield in carats per load	0.41	0.42	0.38
Value per carat	40s. 8.243d.	45s. 9.29d.	40s. 10.47d.
Value per load	16s. 8.179d.	19s. 2.70d.	15s. 6.38d.
Dutoitspan Mine.			
Average yield in carats per load	0.23	0.23	0.21
Value per carat	83s. 0.132d.	93s. 0.45d.	84s. 0.9d.
Value per load	19s. 1.11d.	21s. 4.78d.	17s. 7.87d.

The yield continues to show only minor changes. No blue ground was taken from either the De Beers or the Kimberley mines, a small amount already on the floors of the former mine being washed.

The profit per load shows a slight falling off when compared with 1912–1913, essentially due to a lesser carat-value. The figures for the last 3 years are as follows:

WESSELTON MINE

	Cost of Production per Load	Value per Load.	Profit per Load.
1912	4s. 7.576d.	13s. 1.504d.	8s. 5.928d.
1913	4s. 4.45d.	13s. 10.02d.	9s. 5.57d.
1914	4s. 7.28d.	12s. 9.33d.	8s. 2.05d.

BULTFONTEIN MINE

	Cost of Production per Load.	Value per Load.	Profit per Load.
1912	3s. 11.357d.	16s. 8.179d.	12s. 8.822d.
1913	4s. 1.28d.	19s. 2.79d.	15s. 1.42d.
1914	4s. 4.29d.	15s. 6.38d.	11s. 2.09d.

DUTOITSPAN MINE

1912	3s. 10.665d.	19s. 1.11d.	15s. 2.445d.
1913	4s. 2.09d.	21s. 4.78d.	17s. 2.69d.
1914	4s. 1.49d.	17s. 7.87d.	13s. 6.38d.

The principal data of mining operations for the past 3 years are here represented:

DE BEERS AND KIMBERLEY MINES

	Loads of Blue Ground Hoisted.	Loads of Blue Ground Washed.	Carats of Diamonds Found.	Selling Value per Carat.
1912	323,621	378,614	119,013	53s. 11.47d.
1913	351,347	419,881	120,514 ¾	67s. 3.74d.
1914	None	75,815	27,346 ½	80s. 10.21d.

WESSELTON MINE

1912	2,573,398	2,020,291	581,973 ½	45s. 3.12d.
1913	2,226,157	2,143,232	576,458	51s. 2.88d.
1914	2,373,522	2,083,352	593,305	45s. 7.62d.

BULTFONTEIN MINE

1912	2,334,720	2,025,450	834,760 ½	40s. 8.24d.
1913	2,313,477	2,096,378	874,430 ¼	45s. 9.29d.
1914	2,279,838	2,069,552	785,510 ¾	40s. 10.47d.

DUTOITSPAN MINE

1912	2,718,703	1,845,796	428,213 ½	83s. 0.132d.
1913	2,491,235	2,330,234	540,033	93s. 0.45d.
1914	2,513,469	2,412,679	497,450	84s. 0.9d.

GRAND TOTALS FOR ALL MINES

1912	7,950,442	6,270,151	1,963,960 ¼	.....
1913	7,382,216	6,989,725	2,111,436	.....
1914	7,166,829	6,641,398	1,906,612 ¼	.....

In addition to the direct results from the mines, 765,880 loads of tailings washed in 1914, yielding 82,488¼ carats of diamonds; to this must be added 1,104,577 loads of lumps from which 94,276¼ carats of diamonds were extracted. This would make a total yield for the year, from all sources, of 2,083,376¾ carats.

In computing the visible resources of the company, account must be taken of the blue ground on the floors of the mines, which has been

hoisted but not yet washed. The following figures show the number of such loads (blue ground and lumps) at the close of the year 1913–1914.

	Loads
De Beers	48,396
Wesselton	3,450,638
Bultfontein	3,133,134
Dutoitspan	4,698,854
Total	11,331,022

This already represents a considerable outlay and a large potential source of future returns, the prospective value of the working being emphasized by the following table of blue ground actually in sight.

	Loads
De Beers (above the 2040-ft. level)	2,750,000
Kimberley (above the 3520-ft. level)	2,000,000
Wesselton (above the 980-ft. level)	16,000,000
Bultfontein (above the 1000-ft. level)	10,500,000
Dutoitspan (above the 750-ft. level)	13,500,000
	44,750,000

This, with the stock on the floors, should eventually produce diamonds to the value of from £30,000,000 to £35,000,000.

The value of the Blue-ground Stocks Reserve remained at £2,268,266 The Permanent Reserve Fund is also unchanged at £1,800,000.

Some of the shafts were sunk deeper during the year, the figures now being:

DeBeers:
Rock shaft.....2640 ft.
No. 1 shaft.....1728 ft.

Kimberley:
Main rock shaft.....3601 ft.
Atkins shaft.....1109 ft.
} The open mine has an average depth of 1200 ft. from the surface, the deepest point being 1293 ft.

Wesselton:
No. 1 main rock shaft.....1119 ft.
No. 2 main rock shaft.....1667 ft.

Bultfontein:
No. 1 main rock shaft..... 708 ft.
No. 2 main rock shaft.....1715 ft.

Dutoitspan:
No. 1 main rock shaft.....1424 ft.
No. 2 main rock shaft..... 768 ft.

The Premier (Transvaal) Diamond Mining Co., Ltd., was registered December 1, 1902, and acquired soon afterward that part of the Elandsfontein Farm No. 85, called Prinsloo's portion, for £67,000 in fully paid shares out of the capitalization of £80,000. Not long thereafter the remainder of the Elandsfontein Farm, known as Minnaar's portion, was purchased for £25,650 in cash; the entire area of this holding is about 3300 acres. Additional acquisitions are the Louwsbaken Farm, No. 399, covering 1931 morgen (about 4087 acres), and part of the Kuckerboschfontein, No. 325, with an area of 1136 morgen (2404 acres), and also a part of the Spitzkop Farm, No. 31, with an extent of 928 morgen (1754 acres). A still larger addition to the holdings was made

in September, 1908, when the property of the Pretoria District Diamond Co., Ltd., having an extent of 2335 morgen (4942 acres), was purchased for £21,650. The Premier mine has an area of 3484 claims, and is worked as an open mine, the depth in October, 1914, being 232 ft. An estimate made of the blue ground above the 360-ft. level places it at 33,000,000 loads, which should contain over 6,000,000 carats of diamonds. Tests made to a depth of 1,000 ft. showed that the blue ground still continued to this depth. The government receives as its share three-fifths of the profits over and above capital expenditures.

The capital is but £80,000, divided into 160,000 preferred shares of 5s. each and 320,000 common shares of 2s. 6d. each. No dividends are payable on the common shares until the preferred shares shall have received a cumulative annual dividend of 250 per cent. This has heretofore been regularly paid, the last semi-annual dividend of 125 per cent. having been paid June 8, 1914. On the common shares the dividends have been as follows:

1904–05	400 per cent.	1910–11	500 per cent.
1905–06	400 per cent.	1911–12	650 per cent.
1906–07	400 per cent.	1912–13	750 per cent.
1907–09	Nothing.	1913–14	200 per cent.
1909–10	400 per cent.		

The principal results of the mining operations in the Premier from its organization are as follows for years ending October 31:[1]

Year.	No. of Loads Worked.	No. of Carats Found.	Value of Diamonds.	Yield per 100 Loads, in Carats.	Profit per 100 Loads.
1903	76,931	99,208¼	£137,435 2s. 9d.	129.0	£155 4s. 2d.
1904	939,265	749,653½	866,030 0 5	79.8	79 0 8
1905	1,388,071	845,652	994,687 5 7	60.9	55 4 6
1906	2,988,471	899,746	1,277,739 6 4	30.1	25 7 6
1907	6,538,669	1,889,986¾	1,702,630 19 8	29.0	14 6 3
1908	8,058,844	2,078,825½	1,536,719 19 0	25.8	9 15 11
1909	7,517,793	1,872,136½	1,172,378 7 2	24.9	5 16 9
1910	9,331,882	2,145,832¾	1,496,641 5 5	23.0	5 16 1
1911	8,325,272	1,774,206	1,433,970 6 9	21.3	6 7 5
1912	9,707,098	1,992,474	2,004,943 3 5	20.5	8 13 2
1913	10,434,680	2,107,983	2,336,828 15 1	20.2	9 12 3
1914	7,683,943	1,417,755	1,259,643 5 11	18.5	3 18 9
	72,990,919	17,873,459	£16,219,647 17s. 6d.		

Quotations.—1911, preferred, high 8¾, low 7⅞; common, high 10 1/16, low 6½; 1912: preferred, high 9, low 8⅛; common, high 13½, low 8½; 1913, preferred, high 9⅜, low 8⅜; common, high 13⅜; low 9⅜; 1914, preferred, high 9⅛; low 6¾; common, high 10¾; latest, preferred, 6⅞–7⅛; common, 3⅞–4⅛.

The Twelfth Annual Report of the Premier Mining Co. for the year ending October 31, 1914, covers only 9 months of actual operation, as all work was suspended, because of the outbreak of the war, from

[1] Compiled from the 12 Annual Reports of the company for the years 1903 to 1914, inclusive.

August 10, 1914, when 14,000 native laborers then in the company's employ were discharged and repatriated. For about 300 of the white employes who were unable to find places elsewhere, certain routine work was provided in connection with the removal of the floating reef and in guarding the property. For their wages £4825 was expended in the 3 months and the sum of £550 per month was paid to those dependent on the men who volunteered for service in the field.

Up to the time of the cessation of work the amount of blue ground hauled and washed was about up to the average of the previous year, although the diamond product was less; the number of loads handled was as follows:

From the 260-ft.-level	3,949,156
From the 310-ft.-level	2,922,311
From the 360-ft. level	812,476
Total	7,683,943

The diamond yield was 1,417,755 carats, an average per load of 0.185 carat. During the previous year, 10,434,680 loads had been washed, yielding 2,107,983 carats of diamonds, or 0.202 carat per load.

The Diamond Account shows a credit of £1,259,643, leaving a balance of £302,516, after deducting £906,576 for mining expenses and a little over £50,000 for office expenses, etc. As the value of the diamond stock was diminished £131,272 by the year's operations, the actual balance carried to Expenditure and Revenue Account was but £171,243. After taking from this £49,983 for general equipment, a balance of £121,260 of realized profits remained to be divided between the government of the Union of South Africa and the shareholders of the mine in the proportions of 60 and 40 per cent., respectively.

A preferred dividend of £50,000 (6s. 3d. per share) and two deferred dividends of £140,000 (8s. 9d. per share) and £80,000 (5s. per share) respectively, were paid during the year, the second preferred dividend being passed for the first time since the organization of the company. The 40 per cent. of the realized profits belonging to the shareholders (£48,504) of course fell far short of the amount required for dividend payments, and the necessary sum had to be made up by the balance of £116,567 brought forward from October 31, 1913, by sundry revenue (£44,504) and by an authorized transfer of £47,905 from the Trading and Emergency Funds.

The temporary set-back caused by the war will probably be made good eventually by the realization of greater profits in the period of industrial and commercial activity sure to follow the wasteful conflict. Hence the present unfavorable showing of this mine, and of all other similar interests, leaves the essential worth untouched. A somewhat less satisfactory aspect is, however, offered by the sharp fall in the

diamond yield to 0.185 carat per load, coupled with a decrease in the selling price of the product.

The steady, progressive decline of the yield appears in the following table.

	Yield in Carats per Load.	Value per Load.	Cost of Production per Load.	Profit per Load.
1909	0.249	3s. 1.43d.	1s. 11.42d.	1s. 2.01d.
1910	0.230	3s. 2.49d.	2s. 0.56d.	1s. 1.93d.
1911	0.213	3s. 5.34d.	2s. 2.02d.	1s. 3.32d.
1912	0.205	4s. 1.57d.	2s. 4.79d.	1s. 8.78d.
1913	0.202	4s. 5.74d.	2s. 6.67d.	1s. 11.07d.
1914	0.185	3s. 3.34d.	2s. 5.89d.	9.45d.

As will be noted, although the cost of production was a trifle lower in 1914, the profit per load was only a little over 40 per cent. of that secured in 1913. Of course, the considerable fall in price greatly accentuated the effect of the decreased diamond yield, and with better prices a fair profit could still be realized even should the yield fall slightly lower, but the indication in itself remains a somewhat unfavorable one.

To make provision for hauling from lower levels, two engines, each of 1000 h.p. were purchased, and they reached the mine just after the stoppage of work on the 10th of August. The 360-ft. level has been opened up and 33,000,000 loads of blue ground are available above this level. The average depth of the open workings is 232 ft., showing an increase of 23 ft. over the depth, October 31, 1913.

Priels, Ltd., registered June, 1913, in South Africa, holds the mining rights, with 3-year renewals in perpetuity, of the Priel Estate of 80 acres, the land being partly in the Barkly district and partly in the Kimberley district. For this the payment was £60,000 in paid-up shares, besides the clearing off of liabilities of the former holders, the Priel Diamond Mining Co., Ltd., amounting to £17,000. The income of the new undertaking is to come principally from royalties paid by the diggers to whom the property has been thrown open. Capital £125,000 in £1 shares, of which 100,000 have already been issued and fully paid. Of this capital a controlling interest has been acquired by the South African Diamond Corporation, Ltd.

Roberts Victor Diamonds, Ltd., registered January 6, 1906, in the Transvaal. The property under control is part of a tract known as Farm Damplaats, No. 319, at a distance of 20 miles to the northeast of Boshof, Orange Free State, and has an extent of over 500 acres. It has been leased for 25 years with a renewal right for another term of the same duration, in consideration of a cash payment of £9,000 and £132,200 in full-paid shares. Further acquisitions were the Rietkuhl Farm No. 269,

of 2335 morgen, for which £8636 was given in October, 1906, the Waaihoek Farm No. 102, with an area of 2446 morgen secured in 1907, and 5 morgen of the Waterval Farm, on the south side of the Modder River, utilized for a pumping-station, the Waaihoek Farm being opposite on the north side of the river. Of the prospective profits four-tenths belong to the government, which has, however, agreed to accept £100 per month until 1915 in lieu thereof. The results of mining have been as follows:

	Loads Treated.	Diamond Yield in Carats.	Carats per 100 Loads.
1911	216,968	52,712	24.2
1912	218,362	72,490	33.1
1913	168,334	52,307	31.0
1914 (part)	69,295	16,717	24.1

As the yield was diminishing, owing to a contraction of the "pipe," work in the old mine was abandoned and new ground was opened up to the southwest; operations here have been interrupted by the war. Capital, £160,000 in £1 shares; 150,000 issued and full-paid. Dividends of 50 per cent. were declared in 1907; nothing was paid in 1908; in 1909, 25 per cent. was distributed; nothing in 1910–1912; in 1913—10 per cent. paid in December. *Quotations.*—1911, high 3½, low 15s. 6d; 1912, high 2, low ⅝; 1913, high 47s. 10½d., low 23s. 6d.; 1914, high 1 9/16, low ½; last ⅝.

South African Diamond Corporation, Ltd., registered May 3, 1913, in the Transvaal, the objects being the acquisition of diamond properties and dealings therein. Among the companies in which it has interests are the Priels, Ltd., the New Vaal River Diamond, the New Thor, and the Roberts Victor Diamond Co.; capital £1,000,000, latest quotations, 1–1¼.

Tanganyika Concessions, Ltd., Registered January 20, 1899. Among its acquisitions and holdings is a mineral concession of 60,000 square miles in the Congo Free State. For this 30,000 fully paid shares were given to the former holders, the Katanga Special Committee (Belgian), this body retaining 60 per cent. of the eventual profits. Mineral discoveries here include extensive copper, gold, tin and iron deposits and also diamond-bearing gravel. For the development of the last-named deposits special arrangements have been entered into. The working capital is provided by the Katanga Special Committee, the Zambesia Exploring Co., Ltd., and the Tanganyika Concessions, the first-named providing one-half and the two others each one-quarter. Of the profits 5 per cent. will be set aside as reserve, one-half of the remainder is to be divided between the three companies in the proportion of their contributions to working

capital; of the other half 80 per cent. is to go to the Katanga Special Committee and 20 per cent. to the Tanganyika Concessions. The results of tentative working up to December, 1913, show 187 carats of diamonds from 9315 loads of ground washed. Prospecting for the discovery of new deposits is in progress.

United States Diamond Mining Syndicate, Ltd., registered April 9, 1914 for the acquisition from T. L. West of an option to 363 acres of diamond-bearing land in Elliott County, Kentucky. For the option £500 in full-paid deferred shares was given, the provision being that in case of purchase the price of the land should be $50,000. Capital, £10,500, is divided into 10,000 ordinary shares of £1 each and an equal number of deferred shares of 1s. each. After dividends aggregating 100 per cent. shall have been paid on the ordinary shares, the surplus profits are divisible in the proportion of 50 per cent. each between the ordinary and the deferred shares.

Vaal River Diamond Co., Ltd., registered January 18, 1889. The company secured 140 claims on the Gong-Gong alluvial diggings Vaal River district, Griqualand West, Cape Colony, as well as the freehold of the Gong-Gong Farm and of the Buckland Farm, in all a property of 9285 acres having 3 miles frontage on the Vaal River. The price was £22,500 in cash and £7500 in fully paid shares. The Gong-Gong Farm was sold in December, 1910, to the Diamond Proprietary Mines, Ltd., for £30,000 in fully paid shares of that company, and the Buckland Farm to the Bucklands Estate and Diamond Co., Ltd., for 120,000 fully paid shares of its stock. The capital of the Vaal River Diamond Co. was £50,000 in £1 shares.

Diamantfontein Development Syndicate, Ltd., registered October 24, 1911. This syndicate has acquired a 5-year-option from the Oceana Development Co., Ltd., to purchase three farms known as Diamantfontein, Graspan and Pienaarsfontein, having a total area of 11,725 acres, and located in the Bloemhof district of the Transvaal. The payment for the right was £6600 in cash to the vendors and the same amount to the founders. The option gives a privilege of purchase for £30,000 in cash. Additional options have since been secured, one on the enterprise of the Kunst Diamonds, Ltd.; this has been used, the Roodeplaats (De Beer) Diamond Mines, Ltd., having been organized to take over the rights and holdings. Another option over a mining property at Kroonstad in the Transvaal was acquired in 1914, for an annual rental of £300 and one-third of the capital shares of the Diamantfontein Syndicate, as well as the right to secure any new issues at par. The cost of the Kroonstad property, if 44 claims were brought, was to be £5000 cash, 20 per cent. of any increase of capital, or one-third of the stock of

any new company formed to work the claims; should, however, the whole property be purchased within 3 years, the cost payment would be £15,000.

Diamond Exploration and Finance Syndicate, Ltd., registered February 18, 1902. Possesses share interests in a number of companies, including the Fanti Mines, the Mount Boppy, The Gibraltar Consolidated and the Maikop Premier. Capital, £60,000 in 179,994 common shares of 6s. 8d. each, and two life-governors' shares of £1 each, one of these latter being held by Julius Pam and the other by the estate of the late John Dixon. After a 30 per cent. dividend (non-cumulative) shall have been paid on the common shares, they are entitled to one-half of the surplus profits, the other half going to the life-governors' shares. Of the common shares, 59,950 are issued and fully paid. As the statement for January 31, 1915, shows a debit balance of £10,209, a slight increase over that of the preceding year, the immediate prospect for dividends is not very favorable.

Diamond Proprietary Mines, Ltd., registered December 7, 1910, for the purpose of purchasing the freehold farm of Gong-Gong, Barkly West, Griqualand West, Cape Colony, from the Vaal River Diamond Co., Ltd. The cost of this acquisition was £30,000 in fully paid shares. The area of this farm is 3571 acres, and the revenue of the company is to be derived from one-half of the license-fees of 5s. per claim each month from the diggers, the territory being proclaimed a public digging; the other half is retained by the government. Capital, £50,000, in 200,000 shares of 5s. each, 166,595 being already issued and fully paid. The last statement shows a debit of £436 on profit and loss account.

Frank Smith Diamond Estates and Exploration Co., Ltd., registered March 28, 1900. The company was to acquire the rights of the Frank Smith Diamond Mines, Ltd., and of the Hartz River Diamond and Estates Syndicate, Ltd. This comprised six freehold farms in the Hartz River Division of Barkly West, Cape Colony, with a total area of about 40,845 acres, as well as the 423 claims of the Frank Smith Prospect Diamond Mine. For these rights and properties the sum of £188,100 was paid, mainly in fully paid shares of the new company. Additional territory, farm No. 54, was purchased for £3060 in 1909. Operations for nine months in 1907 gave a yield of 6407 carats of diamonds, about1.6 carat for each 100 loads washed. After temporarily transferring its rights and assets to a new company (the Welgelegen Diamond Co., Ltd.) the original company was reorganized. Work with a new washing plant, having a capacity of 4000 loads per day, resulted in the recovery of 7207 carats-weight of diamonds in the last 6 months of 1913; this was an average of 3.94 carats per 100 loads. For the 7 months

ending July 31, 1914 still better results were attained, 14,665 carats of diamonds being secured from 388,805 loads, giving an average of 3.8 carats per 100 loads. Here, as elsewhere, the war interrupted all operations. Capital, £300,000 in 800,000 shares of 7s. 6d. each, of which 538,250 shares have been issued and fully paid. *Quotations.*—1911, high 12s. 3d., low 4s.; 1912, high 12s. 6d., low 7s. 6d.; 1913, high 15s. 6d., low 5s.; 1914, high 8s. 6d., low 1s. 6d.; latest 1s. 6d.

German Southwest African Diamond Investment Co., Ltd., registered November 25, 1909, in Cape Town, its objects being the acquisition of interests in diamond-mining enterprises in German Southwest Africa, as well as in gold-mining undertakings in the Transvaal. This company secured entire control over the Diamanten Abbau Gesellschaft of Luderitzbucht. Capital, £150,000 in £1 shares.

Griqualand West Diamond Mining Co., Dutoitspan Mine, Ltd., registered September 22, 1881, in Cape Colony. The entire properties of this company were leased in 1889 to the De Beers company at an annual rental of 4 per cent. on the shares of the Griqualand West Co., the debenture debt of £158,000 being also assumed. Capital, £1,057,000 in shares of £10 each. *Quotations.*—1911, high 7¼, low 6¾; 1912, high 7½, low 6⅞; 1913, high 7⅜, low 9; 1914, high 7½, low 6⅞.

Kamfersdam Mines, Ltd., registered April 16, 1896. Acquired 400 diamond mining claims and the freehold of the farm of Kamfersdam, Griqualand West, Cape Colony. This farm on which the mines are located has an area of 10,000 acres, and the price paid for it was £215,000 in fully paid shares. The mining operations for 1905–6 yielded 42,041 carats of diamonds from 594,434 loads of blue ground washed; the output for 1906–7 was much smaller, 13,388 carats being secured from 249,495 loads, the average per 100 loads falling from 7.07 carats to 5.36 carats. Since July, 1907, washing has been suspended, although it would have been resumed last year had the war not ensued. Capital, £400,000 in £1 shares, of which 357,098 have been issued and fully paid; there are also £40,000 of debentures bearing 7½ per cent. interest. The report of June 30, 1914, showed a loss of £20,537 on the year. *Quotations.*—1911, high 10s., low 3s.; 1912, high 14s., low 8s. 6d.; 1913, high 15s., low 10s.; 1914, high 12s. 6d., low 6s. 3d.

Koffyfontein Mines, Ltd., registered May 19, 1893, for the purchase of the Koffyfontein Diamond Mines in the Jacobsdal district of the Orange Free State, comprising about 1000 claims. For this £50,000 in fully paid shares was given, as well as a royalty on all diamonds that might be sold. The holdings of the company were eventually increased to some 1243 claims. The mining results in recent years have been as follows:

	Carats of Diamonds.	Loads Washed.	Average Yield per 100 Loads.
1912–13	64,349	1,119,198	5.7
1913–14	73,966	1,185,793	6.2

On June 30, 1914, there were 2,194,942 loads on the floors; operations were discontinued in October, 1914. This mine has been controlled by the De Beers company since 1911. Capital, £375,200 in common shares of £1 each. For 1909–10 a dividend of 15 per cent. was paid, and one of 10 per cent. for 1910–11; since this year no further dividends have been declared. *Quotations.*—1911, high 3¼, low 1⅞; 1912, high 2⅛ low 1⁹⁄₁₆; 1913, high 2¾, low, 1⁹⁄₁₆; 1914, high, 2³⁄₁₆, low 1⅜;latest 16s. 6d.

Kolmanskop Diamond Mines, Ltd., registered February 5, 1909, in Cape Colony. Organized to secure a 50-year lease on about 10,000 acres of diamond mining property near Luderitzbucht, German Southwest Africa. This was acquired for £100,000, half in cash and half in paid-up shares. The tax due the German government was fixed at 66 per cent. of the proceeds of diamond sales, 70 per cent. of the working expenses and half-a-mark per carat being allowed as rebate. The yield in 1910 was 146,658 carats; in 1911, 147,234 carats; in 1912, 122,525 carats; in 1913, 106,874¾ carats. Capital, £125,000 in £1 shares. Dividends of 55 per cent. were declared in 1909; in 1910, the dividends were 45 per cent., in 1911, 30 per cent., and in 1913, also 30 per cent. The report for year ending December 31, 1913, showed a net profit of £36,365, the Reserve Fund, after payment of dividends amounting to £24,250.

The Modderfontein Proprietary Mines, Ltd., registered March 16, 1903, in the Transvaal, was voluntarily liquidated March 27, 1914, after disposing of its holding, the Modderfontein Farm, to the South African government at a valuation of £5 per morgen (2.11 acres); the area of this farm is 2600 morgen and the company had given £270,000 in paid-up, £1 shares for it.

Montrose Diamond Mining Co., Ltd., registered May 11, 1898, as the Transvaal Diamond Mines, Ltd., the name being changed in April, 1903. It acquired the freehold of the Wrynek Farm No. 74, having an area of 2000 acres and forming part of the Elandshoek Farm in the district of Pretoria, Transvaal. The price paid was £45,000 in paid-up shares. On this property three "pipes" have been discovered. From December, 1911 to February, 1912, 410 carats of diamonds were extracted from 2072 loads of alluvial, equal to 19.3 carats per 100 loads; in the ensuing 3 months the yield was 665 carats for 5223 loads,

12.7 carats per 100 loads. Capital, £200,012, represented by 100,000 preferred shares and 100,012 common or deferred shares, the former being entitled to a 6 per cent. cumulative dividend and one-half of surplus profits over the amount of this dividend; there are also £6000 of debentures bearing 7 per cent. interest. The statement for 2 years, submitted February 25, 1914, showed £54,931 charged to the debit of Development Account. *Quotations.*—1911, high 21s. 6d., low 10s.; 1912, high 16s. 6d., low 9s. 6d.; 1913, high 20s., low 7s. 9d.; 1914, high 5s. 3d., low 1s.

New Jagersfontein Mining and Exploration Co., Ltd., registered May 16, 1887, in the Cape and Orange River Colonies. This company may be said to own all the Jagersfontein Mine, having an area of about 4 square miles, and, in 1911, it added to its holdings the property of the Klipfontein Diamond Mine & Estate Co., Ltd., at a cost of £20,000. The following figures give the results of operations for 3 years, each ending March 31.

	Loads Washed.	Carats of Diamonds.	Value.	Yield per 100 Loads.	Cost per Load.
1912	3,798,831	344,635	£1,116,432	10.62	3s. 5d.
1913	4,173,753	363,397	1,259,983	9.99	3s. 3d.
1914	4,403,383	330,524	1,161,661	8.90	4s. 1d.
Total	12,375,967	1,038,556	£3,538,076		

As the value per load for the year ending March 31, 1914, was 5s. 3.3d., there was a profit of 1s. 2.3d. on each load washed; the average profit in the 2 previous years was slightly higher. Capital, £1,000,000 in £1 shares, of which 850,000 are issued and fully paid. Recent dividends have been as follows:

1910–11	60 per cent.
1911–12	50 per cent.
1912–13	45 per cent.
1913–14	37½ per cent.

Quotations.—1911, high $8\frac{21}{32}$, low $7\frac{7}{16}$; 1912, high $7\frac{9}{16}$, low $5\frac{31}{32}$; 1913, high $7\frac{23}{32}$, low $5\frac{1}{16}$; 1914, high $5\frac{17}{32}$, low $2\frac{7}{8}$; latest, $2\frac{5}{8}$–$2\frac{7}{8}$.

New Vaal River and Exploration Co., Ltd., registered January 25, 1902, in Cape Colony. Its holdings comprise the alluvial diamond deposits of the Vaal River Estate, extending along the Vaal River for about 27 miles, and having an area of 80 acres; this property is situated in the district of Barkly West, Cape Colony, some 30 miles from Kimberley. For these deposits, £106,000 in fully paid shares was given. The holdings of the W. W. Diamond Syndicate, Ltd., were acquired in 1909 for 7800 shares, and those of the River Diamonds Syndicate, Ltd., in the same year, for 17,500 shares. The company receives a royalty on

the diamonds taken from a field it opened up for digging in July, 1902. The returns from the diamond mining for 1911 were 17,139 carats, having a value of £107,000; the figures for 1912 were 26,386 carats, valued at £179,645, and in 1913, 50,070 carats of diamonds were recovered, their value being £336,266. This shows a very rapid increase in the output. Capital, £200,000 in £1 shares, 168,870 of these being issued and fully paid, including 12 founders' shares, the latter being entitled to 20 per cent. of the surplus profit after 20 per cent. annual payment on the common shares. These have received recently the following dividends: April 23, 1913, 10 per cent.; December 13, 1913, 10 per cent.; December, 1914, 5 per cent. *Quotations.*—1911, high 1 5/16, low 5/8; 1912, high 25s., low 10s. 6d.; 1913, high 2 1/16, low 7/8; 1914, high 1 9/16, low 3/4, latest 5/8–3/4.

North Kimberley Diamond Mines, Ltd., registered April 25, 1910. Owns 250 acres of diamond-bearing ground near Kimberley. For this £20,000 in cash was paid to the Ottos Kopje Diamond Mines, Ltd. The government receives a leasehold rent of £1 per acre and also a royalty of 10 per cent. of the amount obtained for diamonds extracted. Results here are still in suspense, washing having been suspended November 12, 1912, up to which date 101,703 loads of ground had been washed, with a yield of 3,428 carats, or 3.37 carats per 100 loads. An average price of £3 11s. per carat was secured for the output. The falling in of a reef, due to an earthquake shock, has been the chief detriment to operations here. The mine has two "pipes" about 200 yds. distant from each other. Capital, £37,500 in 150,000 shares of 5s. each; there are also 6 per cent. debentures to the amount of £14,680.

Orange Free State and Transvaal Diamond Mines, Ltd., registered December 13, 1894, as the Robinson Diamond Mining Co., Ltd.; the name was changed in 1898. The holdings embrace 500 claims including 664 acres of the Kaarvallei Farm and the adjoining Dirksburg Farm with an area of 2389 acres; this was acquired for £15,000, the Kaarvallei Farm having cost £300,000 in fully paid shares. Washing of 77,971 loads of blue ground produced 5444 carats of diamonds, or nearly 7 carats per 100 loads. Capital, £550,000 in £1 shares, all issued and fully paid. *Quotations.*—1911, high 3s. 6d. low 1s.; 1912, high 3s. 6d., low 6d.; 1913, high 2s. 6d., low 6d.; 1914, high 2s., low 6d.

In the diamond diggings of the southwestern Transvaal, there was in 1914 a great falling off in the number and value of diamonds secured; indeed, owing to the general depression in the diamond trade and the local rebellion in South Africa, these diggings were practically deserted toward the close of the year. The following figures are given of the carat weight of diamonds recovered, and of their value, in each month of the year 1914, those for December being estimated:

	Carats of Diamond.	Value.
January	3,064	£12,346
February	3,838	12,167
March	3,865	18,159
April	4,196	18,415
May	4,226	18,739
June	3,549	15,985
July	4,696	19,234
August	2,227	6,623
September	2,104	6,053
October	2,068	5,389
November	833	1,949
December	800	1,800
	35,466	£136,859

These totals compare with those of the 3 previous years as follows:

	Carats.	Value.
1911	37,861	£198,854
1912	79,709	386,668
1913	81,943	422,616

The returns for the first 6 months of 1914, showing 27,738 carats of diamonds, worth £99,811, indicate a greatly reduced production even before the war, as compared with 1912 and 1913; labor troubles are said to have been one of the chief causes of this.[1]

While as a rule all diamond-mining operations in the Union of South Africa were interrupted immediately after the beginning of the war, the Koffeyfontein mine endeavored to carry on work on a small scale, with white men only, so as to provide its white employes with a little remunerative labor as long as possible. To relieve the distress in the Vaal diggings, where so many individual miners are entirely dependent upon their own resources, the Ministry of Mines took measures to secure free railway passes for those who lacked the funds necessary to enable them to return to their homes, to reach some place where they might find employment. In extreme cases, and as an exceptional measure, emergency rations were even issued to those absolutely unable to provide for their daily needs.[2] We have already noted the measures taken by the great diamond companies to relieve, as far as possible, the necessities of their workmen and employes. The Jagersfontain mine is stated to have pursued a similar policy to that of the De Beers company in the treatment of their employes.

The diamond production of South Africa, in 1914, in spite of the cessation of many operations in the latter half of the year, reached a value of £5,487,194 ($27,435,970), the aggregate weight being 2,801,016 carats.

[1] *So. Afr. Min. Jour.*, January 23, 1915.
[2] *So. Afr. Min. Jour.*, August 29, 1914, p. 648.

The following figures show the distribution of the value for 1914 among the three diamond-producing states of the Union of South Africa.

Cape	£3,544,072
Transvaal	1,162,031
Orange Free State	781,091

The value of the diamonds exported from the Union of South Africa in 1913 was $58,476,000, but in 1914 these figures were reduced by more than one-half, to $26,820,000, the exports since the outbreak of the war amounting to less than $1,000,000. This can not be accounted for as in the case of the gold exports (only $2,450,000 during the last 5 months of 1914[1]), by the fear of German cruisers, but really represents the temporary stagnation in the diamond trade.

The number of natives employed in the diamond mines of South Africa just prior to the war was 41,413, these being the figures for June, 1914, published by the Government Department of Mines. Of these 14,509 were working in the Transvaal, 17,698 in Cape Colony and 9206 in the Orange Free State. The natives employed by individual diamond diggers were not included in these statistics. It has been suggested that a considerable number of the natives thrown out of work by the recent shutting down of the diamond mines could be profitably and advantageously employed by the gold mines of the Rand, and it is asserted that this labor element could easily be absorbed in these mines.[2] Certainly the value of gold and the need for an increased supply may be said to be greater now, in time of general financial stress, than ever before, for the task of maintaining adequate gold reserves in the belligerent countries has taxed and is taxing the ingenuity of all the financial ministers, as well as all the leading banking institutions and bankers.

An attempt to secure diamonds on certain of the small Guano Islands off the cost of German Southwest Africa was recently made, but proved decidedly unsuccessful. The expectation had been that the gravel washed up on their shores would yield diamonds, especially as submarine deposits were known to extend for a considerable distance beyond the mainland. However, the only partial success was registered on Possession Island, where 223½ carats of diamonds having a value of £511 10s. were recovered from 3000 loads of the gravel; of these 180 carats came from a belt 20 ft. wide, just about high water, and running east and west for some 300 ft. The tests on the other islands of the group were entirely unsuccessful and as an expenditure of about £8,250 resulted in a diamond yield of only a little over £500, as we have just noted, the enterprise was definitely abandoned.[3]

[1] The gold exports for 1913 amounted to nearly $183,000,000.
[2] *So. Afr. Min. Jour.*, Aug. 8, 1914, p. 589.
[3] Dr. Percy A Warner: "The Diamond Deposits of German Southwest Africa," *So. Afr. Min. Jour.*, October 3, 1914, p. 71.

The progressive increase in the average size of the diamonds found in German Southwest Africa, proceeding from north to south up to a certain point, and the decrease after passing this point, are approximately and broadly shown in the following table:

Locality.	Average Weight in Carats.	Weight of Largest Stone Found, in Carats.
Conception Bay and Spencer Bay	½–1/10	1
Kolmanskop	½–¼	2¾
Stauch and Fiskus Claims	¼–½	3½
Pomona	½–¾	34 3/4
Bogenfels	½–¼	17¼
Frohe Hoffnung	1/16–1/8	3
Angras Juntas	¼–¼	1

The largest stone so far secured precisely within the Pomona territory weighs 10 carats; the large stone credited above to the Pomona district came from land covered by the claims of the Deutsche Diamantgesellschaft, immediately to the south of the Pomona boundary. Another large stone, weighing 33 carats, was found in the same region.[1]

The latest report from the diamond fields of the Belgian Congo notes the finding of some 50 stones in the gold placers of the northeastern part of the colony. The operations of the Kundelunga-Lualaba Exploitation Co. continue to be actively pushed, 13 whites and 250 blacks being employed in the work. While the returns for 1913 at Luanza, showing a recovery of but 218 small diamonds, weighing about 187 carats, from 4390 loads of ground washed, indicate a very low average, less than 0.02 carat per load, further development work here may be attended with better results. In March, 1914, a party of engineers was sent out to test the kimberlite pipes in the Katanga region, which number about seventeen. These diamond deposits are within the sphere of action of the "Société Belge Industrielle et Minière du Katanga," and the claim is made that several new pipes have been discovered in the course of 1914. The development work in the Kasai diamond fields is reported to be progressing.[2]

A second shipment of rough diamonds from the Kasai region, mined by the Belgo-American company, the "Société Forestière et Minière du Congo" was sold in Brussels in March, 1914. The total weight of these diamonds was 4884 carats, of which 1254 carats represented diamonds of first quality, 1303 carats of second quality, and 2327 of inferior quality. The entire shipment was bought by a single firm of Antwerp diamond dealers for $25,494, an average of $5.22 per carat, somewhat less than had been realized on the first shipment, the return,

[1] Dr. Percy A. Wagner: "The Diamond Deposits of German Southwest Africa," *So. Afr. Min. Jour.* September, 19, 1914, p. 40.
[2] Details communicated by Sidney H. Ball.

however, being regarded as favorable in consideration of the slightly lower market rates prevailing and the quality of the diamonds offered.[1]

Australia.—There is said to be some possibility that a Holland-Belgium diamond syndicate may be induced to acquire an interest in the mine and leases at Copeton of the Mount Ross Diamond and Tin Mining Co., should an expert investigation reveal the presence, or satisfactory indications of the presence of a "diamond-pipe" here, or should the deposits promise profitable returns from operations on a large scale. The whole matter is, however, as yet in the stage of tentative negotiation.

South America.—Brazilian Diamond Concessions Syndicate, Ltd., registered June 13, 1911, the object being to secure an option on diamantiferous lands from J. C. Pavia and M. W. Greite, the property being known as Poso Alto and Parauna, in the district of Poso Alto do Serro, State of Minas Geraes, Brazil. For this option the consideration was £3525, of which £500 was payable in cash, £3000 in full-paid common shares. Capital, £10,500, represented by 10,000 common shares and 50 founders' shares, the latter being entitled to one-half of surplus profits after payment of a 10 per cent. dividend on the common stock. Debentures to the amount of £2050 had been issued up to September, 1912, out of an authorized £4,000.

A diamond-mining venture in British Guiana, for some time successfully operated, was the Corona Diamond Syndicate, owned by Hon. John Purroy Mitchel and R. R. Fogel. In 1902, diamonds to the number of 54,740 and weighing 4135 carats were produced. In 1905 Mr. Mitchel remained for 5 months at the mine and during his visit some very fine diamonds were secured.[2]

In 1912 and 1913 mining operations on diamond deposits along the Upper Mazaruni River were quite active, and the results attained have been pronounced satisfactory, the average size of the diamonds being greater than in previously worked areas. One stone weighing 10 carats was found, as well as two others having weights of 6 and 5½ carats respectively; these as well as all other diamonds from these deposits having been secured merely by surface washings. The banks of the Potaro River have also been prospected and the indications for a good diamond yield here are regarded as favorable.[3]

The diamond output of the colony from July 1, 1912 to June 30, 1913 is given as follows:

Mazaruni	71,883	6,841
Cuyuni	3,596	786⅞
Total	75,479	7,577⅞

[1] Vice-Consul General Harry A. McBride, of Boma, Belgian Congo, *Daily Cons. Tr. Rept.*, June 15, 1914.
[2] Communicated by R. R. Fogel, of R. R. Fogel & Co., New York City.
[3] Report of the Gold, Diamond and Forest Industries of British Guiana, 1912–1913.

This compares with 81,034 stones, weighing 6977 carats in the previous year, and with 36,450 stones, weighing 4682 carats, in the year 1910–1911.

The total number of stones reported from this colony in the period from April 1, 1900, to March 31, 1913, was 1,130,494, and the total weight 85,809$\frac{5}{32}$ carats. The average weights were: for 1910–1911, 0.13 carat; for 1911–1912, 0.085 carat; for 1912–1913, 0.10 carat, these figures showing the small size of the stones usually found here.

United States.—The most recent isolated discovery of a diamond in the United States was that of a small trisoctahedral stone at Choteau, Montana, May 17, 1915. This diamond, slightly imperfect and of a brownish hue, weighed 0.13 carat.

Emeralds

The Colombian Emerald Company, Ltd., registered December 22, 1908, went into voluntary liquidation June 8, 1914. The amount of the capital stock issued, £159,000 in £1 shares, was returned to the shareholders in October, 1914, and in addition the sum of 5s. has since been paid on each share. This company was organized to work the emerald deposits at Muzo, Colombia, the sum of £32,000 (£4000 in cash and £28,000 in fully paid shares) being the consideration for the acquisition of the rights. In the year from March 1, 1909 to February 28, 1910, the weight of the emeralds recovered was 182,054 carats; 30,684 of the first class, 49,208 of the second class, and 102,162 carats of the third class. Many inferior stones were also brought up. The liquidation followed the seizure of the mining property by the Colombian government and subsequent litigation.

Garnets

The method employed for mining the almandite garnet of Alaska differs from that generally used in mining gems, in that no explosives are employed. To loosen the garnets from the mica schist in which they are embedded, holes are drilled in this and filled with lime. As the rock formation is soft and dry, the disintegrating effect of the lime suffices to split it up and liberate the garnets. The largest known deposits of this superior kind of garnet are to be found in our Alaskan territory, and a splendid exhibit of these most attractive semi-precious stones, with their ruby-like richness of color—many of the ancient "carbuncles" were of this type—are to be seen in the Palace of Varied Industries at the Panama International Exhibition, where they are shown in connection with the trade exhibits of the methods of cutting precious

stones. All the processes in this art, from the initial stages to the final cutting, as well as the setting and mounting of the cut stones, can be observed by the visitors, who, in watching the deft work of the skilled lapidarists employed here, will gain a better understanding of how much the beauty of the finished gem owes to human intelligence and industry.

PEARLS

For many years there has been an ever-increasing demand for pearls. The world has become richer, pearls have come more and more into favor, and fine pearls are becoming every day rarer, especially in view of the disorganization of industries either directly or indirectly connected with them.

The price of the finer pearls has been maintained, and when business again resumes its normal condition there will surely be a greater demand than ever before, and with the apparent exhaustion of the Cinghalese beds these beautiful gems will certainly lose nothing of their present high value.

It is gratifying to note that recently a motor pump was introduced in pearl-diving, by means of which a diver can descend to the depth of 35 fathoms (280 ft.) instead of to only 15 or 20 fathoms (120 to 160 ft.) as heretofore. At the greater depths larger pearl-shells exist, and the largest pearls are found in the oldest shells. These motor pumps have been introduced into eight different fisheries, and it seems most likely that by their application the pearl yield can be enlarged. When diving to greater depths it is necessary that a diver be taken to the surface less rapidly, because of the rush of blood to the head and the consequent shock to the brain caused by a sudden removal of great pressure.

The finest pearls of the South Pacific are found near the shores of some of the small coral islands of the Tuamotu group about 100 miles eastward from Tahiti. Pearl-fishing is carried on here from August to November under the strict regulation of the French authorities. The different beds are worked successively, an interval of 3 years being prescribed between one fishing season and the next. The pearl-divers, almost all natives, number about 3500, the fishing privileges being exclusively reserved for French subjects. No diving machines or other similar contrivances are permitted, the divers employing the most primitive outfit, large goggles, a loin-cloth, and a rope and weight.[1]

By the terms of a contract made between the government and Gen Diego A. De Castro, of Barranquilla, the latter is given a 5-year concession of the pearl-fisheries along the coast of the Peninsula of Goajoia,

[1] Report of Consul James H. Goodlier, Papeete, Tahiti, *Daily Cons. Tr. Rept.*, Dec. 21, 1914, p. 1236.

from November 20, 1914. The government's share of the net profits is to be 15 per cent. for the first year, 20 per cent. for the second and third years, and 25 per cent. for the fourth and fifth years.[1]

In the Madras pearl-fisheries a serious attempt is to be made to promote the artificial growth of pearls, not only of the so-called "attached" pearls, a goodly number of which have been already produced, more especially in Japan, but of the far more valuable "free pearls," the production of which has not heretofore been attended with much success. The officers of the Madras Presidency Fisheries Department have been interested in the matter, and the methods advocated by Mr. Hornell are to be applied on a considerable scale in an oyster farm established in the waters near Krusudai Island, close to Pamban. The announcement is also made that the chank fisheries on the Coromandel Coast are soon expected to become a good source of revenue, as they have been thoroughly and satisfactorily reorganized.[2]

As in other pearling centers, so in the Thursday Island fisheries, has the production been seriously impeded by the changed conditions since the outbreak of war. The greatly decreased demand from London and its cessation from other parts of Europe, has rendered pearl-fishing unprofitable, a very trying state of things for the inhabitants of Thursday Island, most of whom depend upon this industry for their subsistence. Every effort has therefore been made to continue operations, even on a greatly reduced scale, about half of the boats commonly employed being in use from October to December, 1914, but it was found necessary to dismiss a large part of the Japanese divers, 150 having been sent back to their native land. The number of Japanese still employed is 480, in addition to 60 Malayans and 13 natives of New Guinea. The stringent Australian regulations do not permit the Japanese to land on the island, they being obliged to live continuously on their boats; they are under contract for a 3-year period, all expenses from Hong Kong being paid by the owners of the fisheries. It is found, however, that should the present depression continue, they must all be sent back to Japan.[3]

Rubies

The report of the Burma Ruby Mines, Ltd., for the year ending February 28, 1914, though issued some months before the commencement of the war, compares very unfavorably with that of the previous year 1912–13. Instead of having a credit balance, the Income and Expenditure Account closes with a deficit of £9065 10s. 1d. for the year's opera-

[1] Report of Consul Isaac A. Manning of Barranquilla, Feb. 16, 1915.
[2] *Indian Agriculturalist*, October 1, 1914, p. 318.
[3] From *Honolulu Star-Bulletin*, May 27, 1915.

tions, reducing the balance of £12,412 7s. 4d. brought over from the preceding year to £3346 17s. 3d.

The mining operations for the past 3 years show a progressive decrease in the number of truck-loads of ruby earth washed, coupled with an increase in the cost of mining. The figures are as follows:

	Trucks of ruby earth washed.	Cost of production.
1911–12	1,479,845	7.5 d.
1912–13	1,383,146	7.77d.
1913–14	1,148,155	9.09d.

The increased working expenses for 1913–1914 amount to about £5977 for the ruby earth washed, and this of course accounts in part for the diminished returns. The margin of profit under these circumstances is extremely narrow. These conditions mainly concern the old Mogok Mines; the new Kathé Mine, 8 miles from Mogok, shows better results, and with the steady improvement that has been noted here the setback in the company's affairs may be only temporary. Of course, just at present activity has been checked in these mines, as in the case of the diamond mines of South Africa.

The general weakness in the European ruby market was reflected in a decrease of sales for 1913–14, these reaching only £46,566 11s. 7d., as compared with £65,647 13s. 7d. for 1912–13, a falling off of £9081 2s. To render the financial situation somewhat less pressing the chairman of the Board of Directors has proposed to the Indian government to allow the Burma company the privilege of temporarily retaining the royalties collected, of which the company is only entitled to a percentage for collection. The stock of rubies on hand February 28, 1914, including those sold but not yet paid for at that time, was valued at £58,933 9s. 2d., the corresponding figures for February 28, 1913, being £61,345 11s. 7d.

This company was registered, February 26, 1889, securing from the Secretary of State in Council of India, a 7-year grant, with renewals, of ruby mines in Burma, the rent being 400,000 rupees *per annum* and one-sixth of the net profits. For this grant £55,000 in cash was paid. On May 1, 1904, the lease was renewed for 28 years at an annual rental of 200,000 rupees, in addition to 30 per cent. of all income from the license-holders over 20,000 rupees, as well as 30 per cent. of the net profits. In January, 1912, the Secretary of State agreed to accept, in lieu of annual rent, all payments received for royalties, less a 10 per cent. fee for collection, and half of all net profits in excess of £18,000 until all arrears of rent should be paid. The lease covers a tract in Upper Burma

having an area of about 400 sq. mi., the chief scene of mining operations being the Mogok Valley. A new territory at Kathé, 6 miles distant from Burma, has been mined in recent years. The capital is £180,000, in £1 shares. The following dividends have been declared:

1898–99	5 per cent.
1899–1900	12½ per cent.
1900–01	17½ per cent.
1901–02	17½ per cent.
1903–04	15 per cent.
1904–05	7½ per cent.
1905–06	4½ per cent.
1906–07	8½ per cent.
1907–08 to 1910–11	Nothing.
1911–12	4½ per cent.
1912–13	4½ per cent.

Quotations.—1911, high 6s., low 2s. 6d.; 1912, high 7s. 3d., low 5s.; 1913, high 6s., low 4s. 4½d.; 1914, high 4s., low 2s.

Sapphires

From the appropriately named Sapphiretown, in the Anakie sapphire field, Queensland, Australia, comes the news that concerted effort is being made to encourage the cutting by Australian cutters of the fine sapphires found in this region. At present the greater part of the best sapphires are exported in the rough and are cut in Europe, formerly, to a great extent, in Germany. One of the measures advocated is the imposition of a sufficient import duty on cut stones, and also on the so-called synthetic sapphires. As to the marketing of the Australian output, an offer to undertake this, made by a Sydney firm, has been refused, because the house in question insisted upon having control of the entire production. This was found to be impracticable in view of the multiplicity of separate claims in the sapphire fields.[1]

The sapphire output of the Anakie fields was curtailed the past year, 1914, by the cessation of buying following the disorganization of the gem market. The estimated value of the year's product is £15,800 ($79,000) of which £1600 represented the worth of stones to be used for mechanical purposes, the remainder being the value of the gem-material recovered. This fell far short of the previous estimates for the year, which were put as high as £20,000. It is interesting to note that a good proportion of the Australian supply was cut in the region, where cutting works have recently been established. The value of the sapphires cut in Australia during the year was £5800, some of the material having been produced in previous years.[2]

[1] *Austral. Min. Stand.*, October 8, 1914.
[2] *Austral. Min. Stand.*, February 11, 1915.

Metric Carat

ı effective protest was recently made in England against the undue
r of the Standards Department of the Board of Trade in the allow-
›f variations in the standard carat-weights, this having gone so far
practically nullify the close agreement with the precious-stone
ts used in other countries, which was the chief advantage to be
l by the introduction of the metric carat. As a result of this agita
he following revised scale of allowable errors has been issued by
andards Department:

Metric Carats.	Permissible Error in Milligrams.
500	6
230	6
100	4
50	4
20	2
10	2
5	1
2	1
1	1
0.5	1
0.2 to 0.005	No appreciable error.

QUICKSILVER

By Clifford G. Dennis

The quicksilver industry for 1914 was a great surprise, even to those in close touch with the business. The very low production, coupled with high prices for the metal during the latter part of the year, constituted the principal surprise, while several individual mines contributed a thrill in the way of low or high production.

On the Pacific Coast, the New Idria mine, in San Benito County, California, had a much lower production than for many years. The New Guadalupe mine, in Santa Clara County, California, did not produce as much metal as was expected. The Goldbank mine and the Nevada Cinnabar mine in the state of Nevada, produced more metal than was anticipated. The Chisos mine at Terlingua, Texas, produced more than was expected, considering the unsettled condition on the Mexican border.

The total production in 1914 was less than 1913 by 3645 flasks of 75 lb. each, and of $1339 in value, according to U. S. Geological Survey Preliminary Report. Thirty-six mines and prospects produced metal, of which 26 were in California. In 1913, 24 mines and prospects produced metal, of which 18 were in California.

The California decrease of 4162 flasks was due to the falling off in productiveness of the larger and more important mines of the state. The increase in production in Nevada was due to the continual operation of the Nevada Cinnabar 50-ton furnace, a partial year's operation of the Mercury Mining Co.'s 25-ton furnace, and the operation of enclosed retorts on the Goldbank property. Several prospects in the state were developed to such a degree that an increase in production for 1915 may be expected.

Average prices received for the metal during each month were about as follows:

January	$39.00	July	$35.00
February	39.00	August	80.00
March	39.00	September	75.00
April	39.00	October	60.00
May	39.00	November	55.00
June	39.00	December	55.00

Average $49.50

STATISTICS OF QUICKSILVER IN THE UNITED STATES

Year.	Production.					Exports.			Imports.	
	Calif. (a)	Texas.	Others.	Total.	Value. (f)	Flasks.	Metric Tons.	Value.	Pounds.	Value.
	Flasks.	Flasks.	Flasks.	Metric Tons.						
1900	26,317	1,700	233	974	$1,279,436	10,702	353	$425,812	2,616	$ 1,051
1901	26,720	2,932	75	1,031	1,382,305	11,219	389	475,609	1,441	789
1902	29,552	5,252	.....	1,208	1,515,714	13,247	459	575,099	*Nil.*	.....
1903	32,094	5,029	.....	1,288	1,564,734	17,575	610	719,119	*Nil.*	.....
1904	28,876	5,336	700	(c)1,204	1,348,185	21,064	731	841,108	212	160
1905	24,655	5,000	1,050	1,045	1,217,652	13,460	458	497,470	2,690	1,710
1906	19,516	4,517	1,276	861	1,035,138	6,455	220	244,299	84	50
1907	(d)17,532	3,000	400	712	868,678	5,132	175	192,094	16,566	6,719
1908	(d)16,969	2,832	346	685	903,391	2,995	110	124,960	15,113	8,215
1909	16,217	4,188	810	704	941,233	6,803	231	266,243	15,968	8,203
1910	(d)18,536	3,382	500	763	1,054,991	1,923	65	91,077	667	381
1911	18,860	(g)2,396	.....	732	989,254	291	10	13,995	471,944	251,386
1912	20,600	2,700	1,847	855	1,067,742	310	14	13,360	82,706	39,919
1913	15,396	(h)	4,285	670	774,054	1,140	39	43,574	171,653	75,361
1914	11,485	(h)	5,083	536	811,832	452	15	21,350	685,605	300,000

(a) Reported by the California State Mining Bureau, except 1907–08–10–11. (b) Included in "Other States." (c) Estimated; the weight of the flask was changed from 76.5 lb. to 75 lb. within this year. (d) Figures collected by MINERAL INDUSTRY. (f) Computed at average price at New York. (g) With Nevada. (h) Included in other states.

UNITED STATES

California.—The New Idria mine in San Benito County, notwithstanding its low production, continued to lead the United States producers. Developments are under way in this old property that are likely to open up new ore-bodies, and will facilitate the mining of the low-grade ore known to be available.

The Aurora mine, situated near the New Idria, has been experimenting with a rotary furnace and expects some results in 1915.

The Oceanic mine, in San Luis Obispo County, has experienced a successful year and, according to C. A. Heberlein in an article appearing in the February *Bulletin of the American Institute of Mining Engineers*, Murray Innes has made several very important improvements in his furnace, so that no difficulty is experienced in handling the mud-rock ore occurring in this property. Mr. Heberlein states that by taking advantage of the marcasite (FeS_2) in the ore and maintaining a condition of sublimation in the furnace, 50 tons of ore is being roasted with one-half cord of wood. In other words, the mercury is driven off more rapidly at a low temperature than when a high heat was maintained.

Wet concentration is being practised at the Oceanic mine. A 3½-ft. Huntington mill discharging through 16-mesh screens and feeding direct to a Deister table is stated to be making an extraction of 80 per cent. The costs are higher than direct furnacing, but as it increases capacity very materially it is likely that when considering capital in-

vested, the wet concentration pays, when operated in conjunction with the furnace.

In October work was started at the Cambria mine under the direction of E. Carson. This mine was an important producer from 1906 to 1908 and is likely to become so again.

The Guadalupe mine in Santa Clara County has produced steadily during the year and is likely to remain a steady producer for many years to come.

The New Almaden operated its furnaces during 1914 on croppings, old dumps, and refuse about the furnaces, and made a most creditable record. New work under the direction of W. H. Landers is about to be undertaken and it is likely that the New Almaden will again be an important producer.

At the Helen mine in Lake County, most of the year was spent doing development work with satisfactory results, and the 50-ton furnace was to be started early in the spring of 1915.

At the Oathill mine R. P. Newcomb has installed a wet concentrating plant to treat the old dumps. The ore is crushed and classified, the coarse going to table and the fines to a flotation cell. It is said that a profit is being made on ore yielding 1.5 to 2 lb. Hg per ton.

Quicksilver mines of every description are springing into note through the mine venders at San Francisco, and quicksilver mines are offered that have been and many that never will be. Quicksilver mining in California is profitable in most instances at the present prices of the metal, but it is more than likely that the equipped mines can produce more metal than the country can consume, under normal conditions, so that every new mine put on the producing list means just so much lower a price for all producers under normal conditions, as surplus must be exported.

Texas.—The Chisos mine in Brewster County continued to be the only producer in this state. This mine experienced considerable difficulty in securing labor, due to unsettled conditions along the border, but managed to maintain a very satisfactory production throughout the year.

Arizona.—The Sunflower district reported considerable activity in the manner of new discoveries, also a new discovery was reported from Gila County. No activity was noted at the Cinnabar mine in west central Yuma County. No production was reported from this state.

Nevada.—The Mercury Mining Co.'s property, situated in northern Nye County, closed down its furnace early in the year and confined the work to developing new ore-bodies; the furnace was started again in the fall.

The Nevada Cinnabar Co., situated directly south of the Mercury mine, started its 50-ton furnace and experienced a satisfactory output during the remainder of the year. This plant is one of the best in existence, consisting of a 50-ton Mirabel type furnace, rotary dryer, and eight double condensers. The ore is crushed to ¾-in. ring and delivered to the dryer by a screw conveyor, thence by elevator to a 50-ton bin situated on top of the furnace, from which bin the furnace is fed as required. A 50-h.p. central generating set, driven by a 60-h.p. oil engine, furnishes power and light to the entire plant.

The Goldbanks property situated near Winnemucca erected a battery of inclined pipe retorts, which were discarded, and a set of inclined D retorts were installed. The D retorts are said to be working satisfactorily and a considerable amount of metal was produced during the past year. This company has 300,000 brick made and burned and other material ready for a new plant in 1915.

Several discoveries were reported about Mina during the year but none reported any production.

Oregon.—A discovery of quicksilver deposits was reported as occurring about 35 miles west of Grant's Pass, Oregon, said to be very extensive. The Black Butte mine failed to report any production.

Montana.—A large deposit of cinnabar is said to be under development in west central Montana, but no production was noted.

Foreign

Austria.—Data as to the production of the government-controlled Idria mines have been hard to gather for 1914. This mine produced mercury valued at $644,617 in 1913, employing 997 workmen and 36 foremen, according to Consul Ralph C. Busser. The report states that the cinnabar factory was in operation during the whole year and consumed 54 tons of metallic quicksilver.

The total production for Austria-Hungary for 1913 was 855 metric tons. The Idria mines play a most important part in the present war as it furnishes practically all of the metal for Austrian and German consumption.

Italy.—Italy produced 988 metric tons during 1913 and probably exceeded this amount in 1914. Several shipments were delivered in New York during the latter part of the year. It was this metal that was used by the principal agency to break the domestic price. A rumor in December that the Italian government contemplated the prohibition of the export of quicksilver steadied the American quotations and caused a somewhat higher price to be asked by American producers, although few sales were made.

The Monte Amiata mines in Tuscany are the principal producers of Italy. The mines and geologic features are aptly described by C. de Castro in his article, "Genesis of the Cinnabar Deposits of Monte Amiata," in his book "Le Miniere di Mercurio del Monte Amiata."

Spain.—Spain produced 1490 metric tons of quicksilver in 1913 and probably did not produce more than this amount in 1914, as the production has averaged this amount for several years. The principal mine is the Almaden, controlled by the English Rothschilds under agreement with the Spanish government. All of this metal is marketed through London.

Great Britain.—The imports to and exports from England are estimated from an October report as follows:

	Imports.	Exports.	Price.	
	Flasks.	Flasks.	Highest.	Lowest.
			£ s d	£ s d
1910	44,595	24,748	9 15 0	7 9 0
1911	46,547	31,438	10 0 0	7 10 0
1912	47,261	32,240	8 12 0	4 8 5
1913	45,348	28,816	7 15 0	7 0 0
1914	49,180	25,872		

The home consumption can be estimated under normal conditions as about 11,000 flasks, but under existing conditions was probably much greater.

Mexico.—The Mexican production for 1913 was 150 metric tons and it is likely that less than this amount was produced in 1914, as much of the revolutionary activity occurred about some of the quicksilver mines.

Australia.—The Palgauber Copper and Quicksilver Mining Co. reported in 1913 that they were erecting a Livermore furnace, but nothing further was heard as to its success or failure.

L. C. Ball publishes in the *Queensland Government Mining Journal* under date of December 15, 1914, an interesting article on mercury in Queensland. He describes the Cook district of the Cape York peninsula and calls special attention to the Little River coalfields and their important bearing on the economic status of the neighboring mercury deposits. He mentions the St. George mine and the association of mercury, copper, silver, and gold in the ores of this mine. He mentions one discovery of mercury ore in the Moreton district and goes into the history of mercury prospecting in the Kilkevan district. He shows maps and other data regarding the ores, and altogether produces a most interesting article on this old district where quicksilver has been known to occur, but upon which so little confirmatory data is available.

Metallurgy

Considerable discussion of the multiple-hearth mechanically stirred furnaces has taken place among quicksilver operators. The builders of these furnaces claim that by crushing the ore to ⅜-in. ring and treating in this type of furnace, a considerable saving can be made over the present style of treatment in the Scott type of furnace. The Scott furnace is a hard one to criticize for the reason that while the investment is high from a capacity standpoint, the furnace when properly built is almost fool-proof. It requires a minimum amount of skilled labor and is a most efficient roaster and one that can be situated away off by itself without danger of costly delays and interruptions. The multiple-hearth furnace can be built for a smaller amount per ton of capacity and can undoubtedly be operated successfully on average quicksilver ores and on straight continuous operation possibly at less cost per ton, but it requires more skilled labor and is not anywhere near fool-proof, and would certainly result in many delays through lack of parts and lack of skill in making repairs, when situated away off from the source of supplies as quicksilver furnaces usually are.

Several concentrating plants have sprung up in California and these are attracting considerable notice, due to large capacity for the investment, and hence the fact that much ore of too low tenor for furnacing is being worked by this method. Any combination of gravity concentration and flotation will certainly prove successful on cinnabar ores. It must be a combination of the two processes, however, as the cost of fine grinding is prohibitive for straight flotation and to the fact that in grinding or crushing cinnabar ore a large proportion of the cinnabar goes into slimes and this floats on water very readily even without frothing.

Uses

Fulminate for explosives is probably the greatest use to which quicksilver is being put under existing conditions, although a considerable quantity is being used in the manufacturing of electrical and scientific appliances, for medicines, and in the arts. Paint for ships' bottoms has consumed a considerable amount in the past year and this is looked upon as a great possibility for increasing consumption. The paint, as a red oxide, applied to the bottoms of ships, is said to prevent fouling more successfully than anything else yet discovered.

RADIUM

By Siegfried Fischer

The year 1914 has been a rise and a fall for radium. The early part was alive with interest for the element; the latter part of the year showed a decided decrease in interest, mainly caused by over-propaganda of some men in the medical profession, which finally did not materialize. Many statements regarding the application of radium in the medical profession for curing cancer lacked thoroughness in their investigation, and did not conclusively show the applicability of radium to be an absolute success.

Then, too, the war in Europe eliminated one of the main fields for our ores, large amounts of carnotite being shipped each year to England, France, and Germany. The American medical profession is somewhat slow in accepting the results of a few men as conclusive proof, so that radium in this country is not in very great demand. The cost of the radium salts is, to say the very least, prohibitive for the average physician, so that only hospitals and men of means can afford to obtain sufficient amounts to experiment with. That simmers the buyers of the finished product down to a comparatively small number. We may thus state finally that toward the end of 1914, due to the European war and the limited demand in this country for radium salts, the market as such is disorganized.

In the early part of 1914, bills were introduced in both houses of Congress providing for conservation of radium-bearing mineral lands and participation by the government in the business of producing radium. These bills have been pigeon-holed for the present, and whether or not they will ever be put before Congress is hard to say. The prospectors, having taken their cue from the agitations in the earlier part of the year, have located all the outcroppings or known deposits of radium minerals, and any lands affected by withdrawals now would be difficult to prospect.

New Deposits

Carnotite.—Baraga County, Mich. See under Vanadium.

Pitchblende.—India. See under Uranium.

Radium has been discovered in a spring at Gollitz near Strobnitz, Bohemia. The waters of the spring take third rank in radio-activity.

Market

As already mentioned, the market for radium and radium-bearing minerals is practically completely disorganized, so much so that even the mines of the main producers had to be shut down. This has developed a demand from smaller producers for an American market, and naturally the government is besieged now to buy ores and produce radium. At present the mill of the National Radium Co., under the direction of the Bureau of Mines, is in successful operation.

To increase the market demand in this country it is absolutely essential that the buying price be lowered, so that the finished product may be more readily accessible to the average investigator for experimental purposes. The government has the correct idea. They wish to produce it at the rate of $40,000 per gm. of radium. At present the cost is $120,000 per gm. There is no doubt at all that this last price is far too high and permits a profit for the producer which he naturally is unwilling to give up. Therefore we should not base too much value on reports given out by private concerns making radium products, claiming that it is impossible to make a pure product at such reduced prices as the Bureau of Mines is putting forth. It remains to be seen whether it is possible to lower the present price as far as $40,000, but a little reasoning will incline us to the affirmative, as no matter who does the work, it will not be done without some material gain. So as far as the radium itself is concerned, the future looks bright. It simply remains to create a larger market demand for the element. Naturally, the radium salts will also experience a lowering in price and will come within reach of the average physician.

Radium produced during 1914 can only be gauged from the ore output, which amounted to 4300 tons carrying 22.4 gm. metallic radium; 1200 tons were shipped to Europe, containing 7.2 gm. of radium. Part of this foreign shipment was held in transit due to the war.

Ore was sold on the following basis: By T. F. V. Curran of Placerville, Colo., to Armet de Lisle, Nogent sur Marne, on the basis of hydrous radium bromide, $RaBr_2.2H_2O$, at $19.30 per mg. per ton of ore, for ore containing the bromide between 6–10 mg. per ton. Above 10 mg., 20 per cent. bonus is paid. The ore shipped contained 3–4 mg. and was valued at $60–$80 per ton. W. L. Cummings of Placerville, Colo., was paid at the rate of $2 per lb. of U_3O_8 in the ore. The ore averaged 2 per cent. oxide and was valued at $80 a ton. Foreign figures are not available.

Technology

The investigations of the Bureau of Mines regarding the lessening of the cost of production of radium have as yet not been made public. The

advances thus far made by them are the erection and operation of their concentrating plant mentioned under uranium.

An interesting fact is that S. Radcliff's process is in operation in Australia on the Olary ores. The process in short is as follows: The ore is crushed and magnetically concentrated at the mines. The concentrates are then shipped to Sydney for further treatment. Here they are mixed with three times their amount of salt cake and fused in reverberatory furnaces. The furnace product is ground and leached with water, using counter-current principle. The overflow liquid has a turbid appearance and goes to settling vats. After settling, the supernatant liquor is drawn off and treated for uranium. The slimes containing the radium are collected weekly and extracted for radium. By careful regulation in the initial leaching the residues left in the leaching vats will show no uranium. The turbidity of the solution is caused by radium, barium and lead sulphates carried in suspension in a very finely divided state.

Treating Solution for Uranium.—The solution is led into a vat containing excess mixture of sodium carbonate and sodium bicarbonate. Heat and agitate. Iron and most other bases present are thrown out of solution, while the uranium together with some of the rare earths remain in solution. Filter. Make uranium solution just acid with H_2SO_4, heat to eliminate CO_2 and precipitate the uranium with ammonia. The ammonium uranate is thickened in conical settlers, dried and dehydrated. Break up material and leach repeatedly with hot water to remove bulk of sodium salts. Product left is dried and shows 75 per cent. U_3O_8.

Recovery of Radium.—The residues from the settling tanks are mixed with half their dry weight of strong H_2SO_4 and allowed to stand for several days. Decant and filter. The residues are then boiled in steel tanks with excess solution of sodium carbonate for two days, the solution being replaced once during that time. Wash slimes with water until it gives no reaction for sulphates. The washed slimes are then fed into a warm, dilute solution of HCl, agitated for several hours and allowed to settle all night. Draw off clear solution and precipitate radium, barium and lead as sulphates. Re-treat residues. Product is a mixture of lead, barium and radium sulphates. The separation of the sulphates is not described. The present plant can treat the concentrates from a 10-ton mill per week and the crude sulphates amount to 12 kg. per week.

It is also claimed that a new radium factory is to be put into operation at Dalvait, Scotland, treating ores from which most of the uranium has already been extracted. No information regarding the process to be used is at present available.

New Method for Complex Carnotite Ores.[1]—Crush ore to 40 mesh and roast at 1100° F. in an oxidizing atmosphere. Treat furnace product with

[1] C. W. Danforth, W. P. Samuels, and W. T. Martersteck, U. S. Pat. 1126182.

strong solution of H_2SO_4. Ra and Ba remain as sulphates; V and U go into solution and may be recovered in any of the ordinary ways. The Ra and Ba residues are washed with water until all soluble sulphates are removed. The residues are then treated with a mixed solution of NaOH and Na_2CO_3. Silicates are broken up, form sodium compounds and become soluble. Ra and Ba form carbonates and remain in residue. Filter and treat residue with HCl. This forms chlorides of Ra and Ba. Decant and filter solution and precipitate with H_2SO_4. Get mixed sulphates of Ra and Ba, which can be separate in the usual manner.

Radio Rem.—This is an invention by which water may be charged with radio-act ve rays. Insoluble radium salts are fixed in terra cotta rods. By submerging these rods in water the emanations are absorbed. Rods of the following strength may be obtained:

Radio-Rem C	100 Mache units.
Radio-Rem M	1,000 Mache units.
Radio-Rem X	10,000 Mache units.

Radio-Rem acts similarly to radio-active waters from natural springs and may be used for similar purposes.

The ratio of radium to uranium in carnotite was determined by S. C. Lind and C. F. Whittemore at the Denver office of the Bureau of Mines and found to correspond with that found for pitchblende. It is 3.33×10^{-7}.

[1] Extraction of Crude Sulphates for Radium by Calcium Carbide and Hydride: E. Elber and W Bender, Heidelberg, *Zeit. f. anorg. Chem.*, 88, 255–264.

SELENIUM AND TELLURIUM

By A. S. Callen

During the past year there have been no essentially new developments in the metallurgy of selenium and tellurium. Of the two there is a greater demand for selenium than for tellurium. They are obtained from the slimes of the electrolytic tanks in copper refineries, which contain a considerable percentage of both. They are recovered from the flue dust from the slimes smelting furnaces or by direct roasting of the slimes.

During the year 1914 the selenium market has been practically dead, owing to too fierce competition and overproduction in 1912 and 1913. It is believed that production has been carried on by two companies only, and that at reduced rates. Exports, as far as can be learned, have been about 14,000 lb.; the production of the United States is estimated at about 30,000 lb. Prices opened at $3 @ 3.25 for large lots, and closed nominally at $2 @ 3. There is no demand whatever at present, and all deliveries are being made on old contracts.[1]

From reports of various copper refineries, it is safe to say that enormous quantities of these metals could be produced, if there were a demand for them. Several hundred tons could be supplied at once in the United States alone, if a demand were created, and the possible supply, under a heavy demand, would probably run into thousands of tons.

Selenium is used chiefly in the manufacture of red glass and red enamel ware. The dioxide does not color the glass, but if reduced by carbon, by arsenic trioxide, or by fusing in a reducing atmosphere, the red color is obtained. This red color is probably due to the presence of a selenide, and not to colloidal selenium. The other uses of selenium are mainly laboratory uses, such as in the manufacture of selenium salts and in the production of selenium cells. Small amounts are used in medicine.

Tellurium acts as a coloring agent in glass only under reducing conditions, in which case it will give blue or brown colorations if present as a colloidal solution of the element, or a red if present as the polytelluride. The colloidal particles in the blue glasses are larger than those in the brown. The absorption spectrum of the red glass corresponds to that of an aqueous solution of polytelluride with a characteristic maximum between 480 and 490°. Color is obtained in the glass only under reducing conditions.[2]

[1] *Eng. Min. Jour.*, Jan. 9, 1915.
[2] P. Fenardi, *Chem. Ztg.*, **38**, 873.

SODIUM AND SODIUM SALTS

By Samuel H. Salisbury, Jr.

In the sodium industry nothing new has been developed. The Virginia Electrolytic Co. and the Niagara Electrochemical Co. are the only manufacturers. The latter company uses the Castner process, caustic being the electrolyte and hydrogen a waste product. The annual production of sodium is estimated at 2000 tons. Some details as to recent practice are given in Mineral Industry, 9 and 22. A number of factories have been started in foreign countries. One is reported at the Sognefiord, north of Bergen, Norway. The manufacture of metallic sodium, sodium peroxide, and other compounds is to be undertaken under the title of Frederiksstad Elektrochemiske Fabriker, Frederiksstad, Norway. No imports of sodium into the United States are reported.

Sodium Cyanide

Before sodium cyanide—the commercial product which is now used in gold and silver mining the world over—was placed on the free list, 90 to 95 per cent. of the consumption in America was supplied by domestic production.

Following the removal of the tariff, the reverse became the case—90 to 95 per cent. has been imported, principally from Germany.

The largest plant, although partially dismantled and operated at about one-tenth of its capacity, is still in existence. Before the tariff was removed, the United States produced 16,000,000 to 18,000,000 lb. a year, of which the large plant located at Perth Amboy, N. J., yielded 14,000,000 lb. The owners will probably find it advisable under present conditions to resume operations, provided they can be assured of some protection in the future against foreign importations.[1]

Nitrate of Soda

All known deposits of niter which occur in various desert regions through the world are insignificant compared with the well-known deposits in the deserts of Atacama and Tarpaca, in the north of Chile. These deposits command a great deal of interest, not only on account of

[1] *Eng. Min. Jour.*, Oct. 1, 1914.

their commercial importance, but also for the many attempts which have been made to explain why the quantity of nitrates in this particular region should be so large, compared with any other known deposit.

The first shipment of nitrates to Europe from Chile was made in 1825. Since then the annual exportation has continuously increased until in 1912 the total quantity exported amounted to 2,485,860 tons, of which 1,925,590 tons went to Europe, 469,100 tons to the United States, and 91,170 tons to other lands.

The arid region in which the nitrates are found extends for about 430 miles between 13° and 25° south latitude and lies between the Andes in the east and the Coast Range on the west. This area lying between the two mountain ranges does not form a continuous valley, but is broken up by transverse ranges into a series of elevated basins or plateaus. These plateaus are generally flat or undulating and have an elevation from less than 2500 ft. to more than 5000 ft. They have a general slope from the foot of the Andes toward the Coast Range, and as a result the lowest part of this plateau region, or pampa as it is called in Chile, lies along its western border where it joins the foothills of the Coast Range. It is along this zone that the nitrate deposits occur. The surface of the surrounding region is dry and sandy and vegetation is totally absent. The nitrate beds as they occur in different parts of this region vary in thickness up to about 6 ft. They are usually found at or near the surface, but may in some cases be covered with an overburden to a depth as great as 30 ft. The nitrate deposits are never found pure, but are always mixed with sodium chloride and other salts, and are impregnated with insoluble earthy material. Crude nitrate may sometimes run as high as 60 to 70 per cent. of sodium nitrate, but a deposit running 50 per cent. is considered high-grade material. Material containing less than 16 per cent. is too low grade to be mined at a profit at present.

The source of these deposits is a subject which has given rise to a great deal of discussion. Many theories have been advanced to account for the origin of the nitrates, but all appear to fall short of adequately accounting for all the conditions under which the nitrates are found in Chile. It is generally considered that an organic source is the most probable, but there have not been lacking explanations for the formation of these nitrates which have been based on inorganic agencies.[1]

Of late years a factor which the nitrate trade has to consider is the competition of substitutes such as sulphate of ammonia and synthetic products. As regards the first named, apart from the introduction of possible new processes, there does not seem much prospect of an expanding output, and the carbonizing business is one in which it is very difficult

[1] Wm. H. Ross, *Chem. Eng.*, **20**, No. 4.

to decide what the exact cost of a particular product is, since it may pay to incur loss in one department to maintain profitable output in another. Of the synthetic nitrate business, especially in Norway, great expectations have been expressed. At present, however, we have to deal mainly with estimates. The export last year was 70,171 tons, as compared with 55,000 tons from Chile. Should the industry prove as great as the promoters hope, we may expect the Norwegian government to be no less anxious to participate in the exploitation of its natural resources than is the Chilean government in the nitrate fields. The tax in Chile is, roughly, 4d. per quintal, and possibly arrangements might be made to lower this in cases where the more economical extraction promised us is practised. It is interesting to note that in Norway the government is already opposing to manufacture and export nitrate, and desires to pass an Act regulating concessions for limestone deposits. The Nitrogen Products & Carbide Co. is also stated to be negotiating with the government for the sale of their options on the Toke Falls, thinking, probably, that as lessees from the government there would be less likelihood of a conflict of interests arising.[1]

The factories for the production of azotized cyanamide and synthetic saltpeter are numerous, and are increasing in number, not only in Norway, but in Austria, Italy, Spain, United States and other countries enjoying abundant water-power. It is perhaps debatable whether these artificial manures are of equal value as fertilizers to natural products, notwithstanding that some of the former include a somewhat larger proportion of nitrogen. The competition between synthetic and natural manures promises to become so keen that the Chilean government is considering measures to protect their saltpeter trade. During the last 5 years the price of nitrate, though still permitting a prosperous business, has suffered a notable reduction.

Messrs. Thomson Aikman, Jr.'s half-yearly report[2] on the nitrate industry, dated London, June 30, states that the total advised production for the nitrate year just ended has been about 62,200,000 quintals, against 59,400,000 quintals for the previous year, when the available production, after deducting oficina consumption and "merma," proved only 58,200,000 quintals. That there will prove to be a similar difference between the "advised" and "available" production for the year is considered unlikely, as on stocktaking at January 31 last, it was found that there was up to that date practically no shortage, showing that producers had apparently, without advising the market, been carrying forward their monthly returns on the "net" instead of as previ-

[1] *Min. Jour.*, July 4, 1914.
[2] *Min. Jour.*, July 4, 1914.

ously on the "gross" basis. Shipments during the past year have been about 58,100,000 quintals, against 58,450,000 quintals, and the world's consumption, including losses and loss in weight, about 59,200,000 quintals, against 55,800,000 quintals for the year ending June 30, 1913. During the 12 months three new oficinas started working and four old oficinas, which were stopped, had their maquinas rebuilt. The total production of these amounted to about 1,400,000 quintals, but as their capacity is about 250,000 quintals monthly, an increase during the coming year of about 1,500,000 quintals may be looked for from them. The agreement come to by oficinas representing an annual production of 41,000,000 quintals, to restrict their production for 6 months by 2,050,000 quintals, or 340,000 quintals monthly, terminated at January 31, since which date these oficinas have shown a monthly increase of about 400,000 quintals, and, should there be no restriction or other cause to interfere with production during the coming year, a consequent increase from these of about 2,500,000 quintals appears possible. The oficinas not in the restriction scheme have fully maintained, and in some cases slightly exceeded, the increased rate of production which they attained while the others were restricting, and, as no new oficinas are likely to come in till near the end of the next twelve months, the total increase in production during that period would seem likely to exceed the past year by about 4,000,000 quintals. The total supply of nitrate in sight at date, including stocks in Chile (assuming there has been no shortage in production), and visible supply for Europe, America, and other countries, amounts to about 1,269,000 tons, against 1,139,000 tons at June 30, 1913, being an increase of 130,000 tons or about 2,900,000 quintals. In order, therefore to reduce the supply in sight at June 30, 1915, to the same figure as at June 30, 1913, a consumption for the world of 68–60,000,000 quintals would appear necessary during the coming year, unless the present heavy rate of production is reduced by concerted action on the part of producers, or by natural causes. From above figures it would appear that, after allowing for a normal increase in consumption during the coming year, a restriction of production by 4–5,000,000 quintals from July 1, 1914, to June 30, 1915, is required.

Several meetings, both in London and in Chile, have recently taken place with the object of effecting an agreement to reduce production during the coming 6 months, the individual quotas to be based on the production during January and June, and it is quite possible, with this knowledge in sight, that individual producers have been straining their utmost to attain big figures for January and June, with a view to getting a good quota, and should no agreement be reached some reduction

night nevertheless take place. A large number of producers are also in favor of centralizing sales in the hope of thereby increasing the consumption, and a sub-committee appointed to study the matter has submitted a scheme for this. As, however, the commissions and other costs involved are very materially higher than the present margin of profit on which the trade is worked, it is difficult to see where the benefit to producers would come in, unless the selling price to the consumer is to be considerably higher than at present. A representative meeting of producers to discuss the whole position is being held in London to-day. The cost of production has in most cases shown a slight decrease from the high figures to which it rose last year, and strenuous efforts are at present being made to further reduce same by a new process of manufacture, the inventors of which claim that a reduction of 6d. to 1s. per quintal should be easily attained.

The world's consumption for the year shows an increase of 155,000 tons, or 6.25 per cent. Europe and Egypt have shown an increase of about 180,000 tons, or 10 per cent.; America a decrease of 29,000 tons, or 5 per cent.; and other countries an increase of 4000 tons, or per cent. The decrease in America is to be accounted for by the fact at heavy inland stocks of probably nearly 50,000 tons were carried over t year, and have all been consumed this year, so that the real consption this year has actually been greater than last year. The low l of price now ruling is stimulating purchases for next spring, more cially in Europe, and it is believed by many of the large distributing ers that at the present level of price nitrate is capable of materially nding its consumption, irrespective of the prices of the less popular petitive nitrogenous fertilizers.

Messrs. W. Montgomery & Co.'s report[1] dated London, June 30, s: In our report of December 31 last, we pointed to the probability very large consumption in Europe during the past 6 months, ted that weather conditions were favorable. With the exception of month of March, the weather, for the most part, was probably all could be desired, and an increased consumption of 166,000 tons must, n a producer's point of view, be considered highly satisfactory. The ual figures are 1,497,000 tons, against 1,331,000 during same period t year (an increase of 12.5 per cent.) Production during the same riod (estimating that of June at 5,600,000 quintals), has amounted to 2,169,708 quintals (2,816,000 tons), against 59,450,540 quintals 2,692,000 tons) for the preceding 12 months. Adding stocks, the risible supply for Europe to-day amounts to 400,000 tons, against 420,000, a decrease of 20,000 tons. Great as has been the increase of consumption in recent years, we venture to think that in this direction

there is still an extensive future for the article in Europe, where it had its first introduction, some 60 or 70 years ago, as well as in the states and other countries, which have more recently come to appreciate its fertilizing value. As the years succeed each other so does the population of the world increase, and as a consequence more foodstuffs are required; hence it is that more extensive and intensive cultivation of the land is necessary. We have a strong belief in the ever-increasing demand for fertilizers of all useful kinds; nevertheless, we fail to see that any good end can be served by producers of nitrate of soda forcing the pace unduly as was the case during the past season, and as is still the case, judging by the production figures advised each month. It may be argued that absorption of the nitrate provided proves that it was all required, but this is true in a sense only.

Finding last summer that prices were dwindling away to an unsatisfactory level, owing to apparent over-production, producers made vigorous efforts to bring about a restriction, and were finally able, about the end of August, to announce the completion of a scheme in which 60 per cent. of the producing power agreed to restrict their output for the 6 months ending January 31 by something just over 2,000,000 quintals, or about 90,000 tons. The effect of this declaration (and previous expectations) was to advance the f.o.b. price in Chile about 6d. per quintal, or 11s. per ton—and the figures of 7s. 9d. to 8s. per quintal were maintained throughout the restriction period, therefore producers have no cause for complaint. Unfortunately the scheme was faulty, inasmuch as without the remaining 40 per cent. the 90,000 tons restriction proved to be more nominal than real. The 40 per cent. outsiders made more, and the 60 per cent. in agreement were found, upon the expiration of the term, to have adopted a new method of returning their monthly production. Hitherto the production had been returned on the gross amount from which certain deductions had to be made, but on this occasion it was found that these deductions had already been allowed for in the returns; hence it was that the stock in Chile was found to be at the end of the restriction period 25–30,000 tons more than was looked for. These causes, combined with a heavy fall in freights—steamer freights especially—brought a greater supply of nitrate to market for the actual consuming season than had ever been anticipated. Thus was the market weighted from the commencement of the season with a supply actual and prospective, and although the consumption has proved itself beyond expectations, considering the abnormally wet March through which we passed, the supply was at all times in too great abundance to permit of any buoyancy in prices. Such being the case, the incessant rain which prevailed throughout the month of March acted upon the

nerves of holders, who hastened to relieve themselves of their holdings at prices a long way below the equivalent of those paid to producers for f.o.b. nitrate in Chile.

What the trade is suffering from is over-production. If producers, for instance, show that they are producing a quantity of nitrate for the season which is 5–6,000,000 quintals, or about 250,000–300,000 tons, more than the consumers' hitherto known capacity of absorption, they must expect to find buyers very chary of entering into forward engagements on the "bull" side; not only so, but they need hardly be surprised if some of those engaged in the trade take the view that the chances are in favor of a very bad market and operate the other way; hence unsteadiness all along the line. Of course, if some central body, which may yet be created, took the risk upon themselves, it might be found that, with the development of the season, the whole quantity would be required, but if not—what then? Meantime, production goes on apace, and only a drastic and immediate curtailment will stay the inevitable sagging of prices. Even the largest and cheapest producers will, ere long, realize that if dividends are to be made it will be perilous to leave the market longer to struggle with what is to-day an apparently prospective excessive supply. Negotiations of some sort are, we understand, going on between the Nitrate Committee here and the Iquique Committee, but as there are two schemes in the field—namely, "restriction" and "centralization," much valuable time (and a considerable amount of money to the producers themselves) is being lost while they decide which of the two will be the more effective in bringing about a normal and healthy market. Whatever virtue there may be found in "centralization" when its details are unfolded, it is almost certain that "restriction" will have to be employed as a stop-gap in the meantime if prices are not to be allowed to descend to a figure which will cause many oficinas to close down, and thus put a check upon production, and perhaps for a short time enable the survivors to obtain what they are probably aiming at to-day—viz., a price of about 8s. per quintal f.o.b. Chile.

The nitrate industry, has suffered very severely from the war. Already in a situation of some difficulty, owing to production in excess of consumption, and struggling to arrive at an agreement among consumers for an effective limitation, it was struck by the blast of war and great disorganization ensued. So far as can be judged, no concerted movement has yet proved practicable to deal with the situation, involving as it does the world's chief market. Germany, Austria, and Belgium are, of course, closed to all imports, and in the United States the difficulties in the cotton industry are likely to lead to a considerable reduction in

requirements there also. In addition, we have the fact of the disorganization of the beet sugar industry, not to say the uncertainty of how long the interference with extensive areas of the world's agriculture will continue.

The ordinary figures of production, shipment, stocks, etc., are necessarily of a fragmentary character for the period since the outbreak of the war. Mr. Thomas Aikman, Jr., estimates the production in Chile for the second half of the year at 965,000 tons, making with the 1,455,000 tons in the first 6 months a total of 2,420,000 tons for the year, against 2,730,000 tons in 1913. Shipments are put at 1,754,000 tons, against 2,696,000 tons. Of the total shipped, over 100,000 tons is believed to be in German shipping interned in neutral ports. As will be seen, there has been a large accumulation of stocks in Chile amounting to 1,118,000 tons, compared with about 490,000 tons for the 2 years previous. There has been great dislocation of the officinas working previous to the war, which, according to the latest reports, numbered forty-three, and the expectation is that some of these will close as soon as their existing contracts run out. Messrs. Montgomery & Co. point out that even at present the production is in excess of requirements, and that the present price of about 6s. per quintal is not one which economically justifies production. Here, however, as in other mining fields, the desire to maintain labor, which once scattered is not easily recalled, is probably operating to modify purely economic considerations.[1]

The following table shows the shipments and consumption of nitrate of soda for the last 13 years.

NITRATE OF SODA STATISTICS (a)
(In tons of 2240 lb.)

Year.	Shipments from South America.	Consumed in Europe.	Consumed in United States.	Consumed in World.	Stocks in Europe.	Visible Supply at Close of Year.
1900	1,429,000	1,126,000	175,000	1,324,000	221,000	794,000
1901	1,238,000	1,154,000	192,000	1,364,000	243,000	617,000
1902	1,360,000	1,028,000	214,000	1,259,000	263,000	660,000
1903	1,435,000	1,127,000	265,000	1,412,000	155,000	654,000
1904	1,476,000	1,131,000	275,000	1,447,000	162,000	672,000
1905	1,623,000	1,190,000	308,000	1,547,000	183,000	674,000
1906	1,700,000	1,243,000	355,000	1,636,000	190,000	733,000
1907	1,626,000	1,252,000	350,000	1,658,000	202,000	695,000
1908	2,017,000	1,378,000	309,000	1,732,000	402,000	928,000
1909	2,100,000	1,465,000	407,000	1,938,000	337,000	999,000
1910	2,300,000	1,651,000	501,000	2,241,000	310,000	969,000
1911	2,412,000	1,696,000	550,000	2,355,000	479,000	1,058,000
1912	2,478,000	1,908,000	481,000	2,508,000	310,000	1,004,000
1913	2,655,000	1,775,300	.....	2,520,000	.....	1,146,000

(a) Statistics of W. Montgomery & Co., London.

Practically no niter is produced in the United States, although a few

[1] *Min. Jour.*, Jan. 9, 1915.

deposits are known. All the nitrate consumed in this country is imported from Chile, the amounts being shown in the following table:

IMPORTS OF SODIUM NITRATE INTO THE UNITED STATES (a)
(In tons of 2240 lb.)

Year.	Quantity.	Value.	Value per Ton.	Year.	Quantity.	Value.	Value per Ton.
1903.....	272,947	$8,700,806	$31.88	1909.....	422,593	$13,281,629	$31.43
1904.....	228,012	9,333,613	40.93	1910.....	529,172	16,601,328	31.37
1905.....	321,231	11,206,548	34.89	1911.....	544,878	16,814,256	30.86
1906.....	372,222	14,115,206	37.92	1912.....	486,352	16,668,404	34.25
1907.....	364,610	14,844,675	40.71	1913.....	625,862	21,630,811	34.56
1908.....	310,713	11,385,393	36.64	1914.....	543,715	15,228,671	28.00

(a) As reported by the Bureau of Statistics, Department of Commerce. The figures of value appear to be doubtful, especially with respect to the earlier years.

Niter in the United States

In this country few nitrate deposits are to be found apart from those of cave origin. The most extensive so far known occur in San Bernardino and Inyo Counties, California, along the shore lines or bed beaches of what was supposed to be a former sea, but which is now geologically known as Death Valley. The region popularly known as Death Valley is that portion of the valley proper which is below sea level. The territory covered by nitrate beds has been estimated to cover an area of about 35,000 acres. Through erosive agencies the clay beds in which the nitrates were deposited have been worn into buttes and ridges of characteristic shape and color. The hills so formed vary from only 50 ft. to over 300 ft. high. Samples taken from the niter-bearing strata in the hills, and exposed by erosion, vary all the way from a trace to more than 50 per cent. of nitrates. It is generally agreed that these deposits have not been formed *in situ*, but have resulted from the concentration of nitrates formed from the decomposition and nitrification of animal and plant life which must have existed in the region at the time that the valley was filled with water. Owing to the limited distribution of these nitrates they are not considered of much commercial importance, and the same may be said of all other deposits so far discovered in this country.[1]

Florida.—It is reported that a company has been organized and the representatives of the concern are now in Florida and prepared to open up to commerce the natural nitrate deposits in the gulf section of the state, and that a railroad is to be built connecting the deposits back in the forest with railroads leading both to deep water and to northern railroad connections.

It is also stated that Hillsborough County is known to have large areas

[1] *Chem. Eng.*, Oct., 1914.

where once the egret and other birds denizened in multitudes, and it is likely that deposits will be found there.[1]

Idaho.—Niter has recently been discovered near Homedale, Idaho. The field lies in and about the valley of Sucker Creek, in Malheur County, southeastern Oregon, near the state line and about 16 miles southwest of Homedale. Two general classes of deposits have been recognized: (1) crevice and cave deposits in the lavas bordering Sucker Creek, and (2) more or less bedded deposits in low rounded hills composed of sedimentary materials.

The first class includes the nitrate deposits. They occur in crevices usually only a fraction of an inch wide, distributed in more or less indeterminate zones a few feet in width, where the fractures and shelly lava form the protected cliff faces of small recesses or caves, and at the base of cliffs, along the soil line, at the same localities. The more abundant deposits of the first class thus far discovered are those at the soil line. The main deposit available seems to be that in the crevices in the rock, but it is doubtful if the nitrates have any great extent or volume within the rock mass. The percentage of nitrate present in the rocks is very small in comparison with the body of rock that would have to be handled if any attempt were made to recover the nitrates for commercial purposes. The amount is probably not more than 1 or 2 per cent.

Analysis in the laboratories of the U. S. Geological Survey shows that the crevice and cave deposits consist largely of nitrates of sodium and potassium, with some other nitrates and accompanying sulphates of sodium, magnesium, and aluminium.

It is comparatively easy to separate by hand the better nitrate material from the sulphates which occur in the same crevice and in adjacent crevices. One hand-picked specimen of this selected material yielded 90.6 per cent. of total nitrates. Another sample more nearly representative of the average material yielded 64.7 per cent. of nitrates, chiefly sodium nitrate. This figure is higher than the percentages usually found in the better grades of saltpeter mined in Chile.

In picking down the rock for commercial treatment, however, separation of the better material from the sulphates would not be practicable, and the nitrate deposits, though of good quality, appear therefore to offer little hope of successful development. Deposits of this character are widespread throughout the arid and semi-arid regions of the West, extending from Oregon to Texas.[2]

Some niter of more or less value has been discovered in Montana and was noted in MINERAL INDUSTRY, 22.

Small nitrate deposits are also to be found in various other parts of

[1] *Amer. Fert.*, Jan. 23, 1915.
[2] *Amer. Fert.* March 20, 1915.

world, as in the Sahara, in Russian Turkestan, and in Egypt, where ate earths occur which contain about 15 per cent. of calcium and ium nitrates. The earth has long been used locally as a fertilizer and use is supposed to be increasing. The source of the nitrates in this on is not known.

IMPORTS OF SODIUM SALTS (*a*)
(In tons of 2000 lb.)

	1910.		1911.		1912.		1913.		1914.	
	Tons.	Value.	Tons.	Value.	Tons.	Value.	Tons.	Value.	Tons.	Value.
iate.....	242.3	$14,368	84.2	$5,199	178.3	$11,195	634.0	$55,941	114.1	8,267
.....	2,495.0	55,262	1,939.1	43,365	1452.7	33,459	1550.4	35,461	1,114.5	28,102
bonate.....	73.2	4,472	42.6	2,634	55.0	3,193	40.3	2,238	44.4	2,324
omate and mate.....	1,332.1	101,687	.....	1	.....	.....	.....	3	5.5	542
tic.....	519.4	33,882	1,492.1	73,968	465.3	28,937	335.7	25,364	332.7	23,914
onate stal).....	69.9	2,569	152.6	4,235	177.3	5,616	84.6	2,928	103.7	309
rate.....	.....	.....	.....	2	.....	22	.....	10	0.2	84
ide (salt)..	138,376.2	374,420	141,227.8	390,043	145,041	379,539	125,428	356,911	16,987.5	456,426
sulphite....	22.3	626	14.7	612	4.3	277	3.6	228	463.1	128,828
te.....	542,334.0	16,548,036	546,394.6	17,101,155	481,786	15,427,904	656,672	20,713,375	620,533.2	17,926,165
te.....	566.3	52,237	238.8	21,205	487.3	47,399	634.8	57,595	922.2	76,813
phate.....	31.0	1,045	22.0	750	.....	.....	.....	14	682.4	24,975
iate.....	649.9	76,648	598.0	66,971	823.2	90,654	943.7	118,475	1,147.9	171,831
oda.....	241.1	4,630	107.2	1,512	126.8	2,020	64.0	1,010	81.8	1,274
ake.....	3,928.0	40,640	11,398.1	121,218	659	8,394	189.1	4,771	31.4	618
te.....	599.5	12,994	617.3	11,713	466.6	8,870	516.1	9,400	523.3	10,881
ide.....	298.3	9,086	228.0	4,751	361.5	10,456	475.8	12,360	1,265.0	36,383
ite.....	125.5	4,082	493.7	14,810	177.1	4,860	13.6	400	191.3	5,627
ate.....	.....	.....	.....	.....	.....	.....	336.3	5,685	455.1	7,475

) For fiscal years ending June 30.

SODA

Africa.—The directors of the Magadi Soda Co., Ltd., have issued a ular to the shareholders stating that from advices received from t Africa the interruption of the construction work is likely to be of siderably longer duration than was originally anticipated. The nch line to the Magadi Lake is entirely under military control, and lian traffic of any description is only allowed at intervals when con- red safe by the military authorities. The final completion and asting of the railway by the contractors as well as the erection he works at the lake, which is largely dependent on the use of the , are practically at a standstill. The erection of the subsidiary ks, both at Kilindini and elsewhere, which will work entirely on material supplied from the lake, has either been stopped altogether the present or considerably curtailed in order to husband the com- y's financial resources. All works of this description which will required on the commencement of trading are sufficiently advanced nsure that they can be completed and put into working order within time still required to complete the works at the lake after the re-

sumption of normal operations. In the meantime the company will be incurring expenditure not anticipated in the original prospectus, and the estimates, owing to this delay, are likely to be considerably exceeded. Practically the entire staff in British East Africa has been enrolled in the defence forces, and in agreement with the general manager on the spot the board is making such provision as is considered reasonable for them.[1]

California.—Large amounts of various sodium salts, particularly the borate, carbonate, and bicarbonate, occur at Searles Lake.

Among the minor saline minerals here, salt is the most abundant. Above ground, salt occurs in three or four types of deposits. The scaly deposit is the result of evaporation. A thin crystalline coating collects on the surface of pools of water. This coating, being broken up by winds, sinks to the bottom of the pool, further crystallization cementing the scales together. There also exist an efflorescent crust, largely of salt, a foot in depth and covering a considerable area. This habit is not generally known to salt, and it is possible that it may occur through replacement of sodium carbonate or sulphate.

Below the surface crystalline masses of salt are found in nearly all parts of the lake. At points these crystalline beds are found to be 20 ft. or more in thickness.

Hanksite, thenardite, ulexite (cottonball), and glauberite occur here in greater or less quantities.

One of the vagaries of nature here is the occurrence of the trona "fish-bone" crystals. These crystals were first discovered by F. C. Ware in 1910, in a delta of sandy mud which cuts the soda reef. They have very much the appearance of flat tapering splinters of wood and occur like roots, projecting into the ground vertically as deep as 6 or 7 in. The tops of these "fish bones" rise just to the surface of the mud and only the exposed top has definite crystalline planes.

They were at first thought to be gaylussite, their appearance and growth being similar to the "nails" of the Venezuelan alkali makers. Their analysis, however, shows Na_2CO_3 45.89 per cent., $NaHCO_3$ 31.90, H_2O 17.67, insoluble 32.7 per cent. It is possible, of course, that they are pseudomorphs after gaylussite. Indeed, this interchange of personalities has also been observed in gypsite, which has been found almost entirely replacing the sodium sulphate in the cruciform thenardite crystals.

The knowledge of the value of these deposits lay dormant for many years, and it was not until 1905, when C. E. Dolbear commenced investigating the extent of the deposits and their commercial possibility, that this dormant condition was dispelled. In 1908 he organized the

[1] *So. Afr. Min. Jour.*, Nov. 28, 1914.

California Trona Co. for the purpose of operating, first, the surface deposits. This company acquired the old borax works, and in the fall of 1908 commenced the construction of a plant with the capacity of 100 tons per day of soda ash.

According to C. E. Dolbear, the percentage of potassium chloride in the brines is quite uniformly 4.49; that of the solids, 3.46. His estimate of the total potassium chloride content in salts and brines is approximately 30,000,000 tons. Calculations of other salts of major importance are sodium biborate (anhydrous), 17,100,000 tons; sodium carbonate, 115,130,000 tons; sodium bicarbonate, 42,700,000 tons.[1]

Salt

Salt occurs in two distinct ways—as rock salt in beds or associated with bedded or sedimentary rocks, and in solution, as in sea water or in brines or bitterns. A very large part of the salt production is derived by converting the natural rock salt into brine, which is then pumped to the surface and evaporated.

The two main methods of obtaining salt are the mining of rock salt and the evaporation of salt-bearing solutions. Rock salt is produced chiefly by deep shaft mining in the eastern, central, and southern parts of the United States. Active mines are located in Livingston County, N. Y.; near Detroit, Mich.; in Ellsworth and Rice Counties, Kans.; and in Iberia Parish, southern Louisiana. A small production comes from surface deposits in the dry climates of Utah and California. In 1913 the marketed production of rock salt in the United States was 1,062,291 short tons, valued at $1,968,567.

The processes employed at the present time in the manufacture of salt by evaporation are solar evaporation, direct heat evaporation, steam evaporation, and vacuum pan evaporation. Salt is made by one or more of these processes in the great majority of the salt-producing states. California is unique among these states in that the great bulk of the salt produced in that state comes from sea water, being obtained by solar evaporation on San Francisco Bay, near Long Beach and near San Diego.

Michigan ranked first among the salt-producing states in 1913 in both quantity and value of production, followed by New York, Ohio, and Kansas in the order named.

The production of salt in the United States is shown in the following table:

[1] S. H. Dolbear, *Min. Eng. World*, Oct. 31, 1914.
[2] U. S. Geol. Surv.

PRODUCTION OF SALT IN THE UNITED STATES (a)
(In barrels of 280 lb.)

Year.	California.	Kansas.	Louisiana.	Michigan. (c)	Nevada.	New York. (c)	Ohio, W. Virginia, and Pa. (b)	Texas.	Utah.	Other States.	Total, Barrels.
1904	821,557	2,161,819	1,095,850	5,425,904	(d)	8,600,656	3,030,829	.....	253,829	639,558	22,030,002
1905	664,099	2,098,585	1,055,186	9,492,173	(d)	8,359,121	2,728,709	(d)	177,342	1,390,907	25,966,122
1906	806,788	2,198,837	1,179,528	9,936,802	11,249	8,978,630	3,436,840	(d)	262,212	1,361,494	28,172,380
1907	626,693	2,667,459	1,157,621	10,786,630	6,459	9,657,543	4,007,390	(d)	345,557	464,143	29,719,495
1908	899,028	2,588,814	947,129	10,194,279	9,714	9,005,311	3,572,635	(d)	242,678	1,291,042	28,750,630
1909	886,564	2,769,849	(d)	9,966,744	16,107	9,880,618	3,835,267	(d)	246,935	2,505,562	30,107,846
1910	937,514	2,811,448	1,372,248	9,452,022	17,535	10,270,272	3,829,475	382,164	249,850	983,128	30,305,856
1911	1,086,163	2,159,859	(d)	10,320,074	12,856	10,082,656	4,485,886	385,200	272,420	2,391,710	31,196,824
1912	1,090,000	2,573,626	(d)	10,946,739	12,536	10,502,214	5,408,300	373,064	283,293	2,135,036	33,324,508
1913	1,082,993	2,698,079	(d)	11,528,800	8,971	10,819,521	5,424,056	355,529	330,443	2,189,913	34,438,305
1914	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	34,804,653

(a) Statistics of the U. S. Geological Survey except for New York since 1905, which are from reports of the State Geologist. (b) The production of Pennsylvania since 1905 is included in "Other States. (c) Includes brine used in manufacture of alkali. (d) Included in "Other States."

CONSUMPTION OF SALT IN THE UNITED STATES
(In tons of 2000 lb.)

Year.	Production.		Imports.		Exports.		Consumption.	
	Amount.	Value.	Amount.	Value.	Amount.	Value.	Amount.	Value.
1900.....	2,921,708	$6,944,603	199,909	$634,307	7,511	$65,410	3,114,106	$7,513,500
1901.....	2,879,332	6,617,449	201,733	676,324	9,433	86,414	3,071,632	7,207,359
1902.....	3,338,892	5,668,636	184,764	647,554	5,094	55,432	3,518,562	6,260,758
1903.....	2,655,532	5,286,988	165,981	495,948	12,750	95,570	2,808,763	5,687,366
1904.....	3,084,200	6,021,222	166,140	467,754	13,964	113,625	3,236,376	6,375,351
1905.....	3,635,257	6,095,922	161,159	492,189	34,238	239,223	3,762,178	6,348,888
1906.....	3,944,133	6,658,350	170,505	502,583	33,988	274,627	4,080,650	6,886,306
1907.....	4,160,729	7,439,551	153,435	452,227	30,802	232,895	4,283,362	7,658,883
1908.....	4,024,345	7,486,894	156,609	440,484	26,627	202,338	4,154,327	7,725,040
1909.....	4,215,070	8,343,831	158,487	447,983	40,158	269,273	4,333,397	8,522,541
1910.....	4,242,792	7,900,344	142,549	388,015	49,013	320,926	4,336,328	7,967,433
1911.....	4,365,756	8,345,692	137,759	378,083	48,873	335,285	4,454,642	8,397,490
1912.....	4,665,473	9,402,772	136,391	361,664	62,410	418,525	4,739,454	9,345,911
1913.....	4,821,368	10,123,129	150,601	416,375	70,289	515,194	4,901,680	10,024,310
1914.....	4,872,656	10,271,358	132,970	385,752	82,195	586,055	4,923,431	10,071,055

The domestic production of salt for 1914 will probably be about the same as in 1913. For accounts of the occurrence and production of salt in the several leading salt-producing states, see MINERAL INDUSTRY, Vol. 22. These states are California, Michigan, and New York, and they produce the bulk of the domestic salt; Louisiana is also an important producer of salt in the form of rock salt, in which it ranks second among the states. The salt mines underly so-called islands, which are really mounds rising above the marsh lands along the Gulf shore of Iberia Parish. The Petite Anse mines on Avery Island were operated during the Civil War, having been developed in a small way in 1862. These mines were flooded twice and a new shaft was sunk in 1890. Mining on Weeks Island began in 1902. The extent of the Weeks Island deposit, which is operated by the Myles Salt Co., of New Orleans, has been demonstrated by borings to cover at least one-half of the island which contains 2000 acres of highlands.

The deposit, which is in a solid mass, goes down to an unpenetrated depth of at least 4000 ft., a near-by boring having been driven down 3800 ft. The output of the present plant on the island averages about 10,000 tons per month and is constantly increasing. About 12,000,000 tons of salt have been taken out of the mine since mining operations began and it is estimated that there are still 5 billion tons left on the level upon which they are working at the present time. This level is at a depth of about 600 ft. The salt produced is so pure that it needs no treatment other than grinding, analyses having shown it to run 99.84 per cent. sodium chloride.

Pennsylvania (By Richard R. Hice).—While Pennsylvania was at one time a large salt producer, the production has been gradually decreasing until for several years there have been but two producers remaining. Both of these plants were located on the North side, Pittsburg, the brine used coming from wells at the plants. The source of the brine was probably the Berea grit.

Both the plants in Allegheny ceased operations some time in the year 1913, and so far as known there was no production of salt in 1914.

Foreign Countries

Africa.—There is a possibility of a salt industry being developed in Senegal, and the subject is now being studied on the spot. The results have so far proved satisfactory, and it is reported that a salt market of some size will be established in the Saloum. The persons interested have already obtained some land concessions upon which they are shortly going to begin work.[1]

Bahamas.—A Chicago corporation contemplates leasing a tract of at least 1000 acres on Inagua, one of the Bahama Islands, widening and deepening a canal to admit barges of 300 or more tons, and establishing a big salt-making plant. Auto-trucks would be loaded at the salt pans and convey the salt to lighters. The trucks would carry 8 tons of salt. At present private firms pay 2 cts., United States currency, for hauling their salt to warehouses, while other expenses bring the total cost up to 5 cts. for placing the salt on steamers. The price paid for the salt is only 6 cts., which is too close a margin. The American corporation could reduce the expenses greatly. A steamship line has offered to carry the salt to New York at a nominal rate. Thence it would be conveyed in meat cars returning to Chicago, usually empty. A dozen industries allied with this corporation would require salt.[2]

Canada.—Extensive beds of salt or salt-producing springs are found in nearly every province of the Dominion of Canada.

The largest, and at present the only, producing district, is situated in

[1] *Chem. Tr. Jour.* and *Chem. Eng.*, Dec. 12, 1914.
[2] Consul W. F. Doty, Nassau, *Daily Cons. Tr. Rept.*, Oct. 12, 1914.

the southwestern peninsula of the province of Ontario, bordering on Lake Huron, the St. Clair River, Lake St. Clair, and the Detroit River. The salt here exists as beds in the Salina formation of the Silurian system, which formation in the productive area is covered by upward of 1000 ft. of other strata, chiefly Devonian.

In this district the principal plants are located at Windsor, Sarnia, Sandwich, Goderich, Clinton, and Kincardine. A prominent feature of the salt produced from the brine in Canada is its remarkable purity and also its freedom from other salts detrimental to its use in the production of caustic soda and bleaching powder. There is a good opportunity for the soda industry in the Dominion, and it is assuming larger proportions each year. At Sandwich a plant has been recently erected for the manufacture of caustic soda and bleaching powder from the brine.

The production in Canada is obtained wholly from the evaporation of salt brines, either natural, or else formed by the pumping of water down drill holes to the salt beds and the re-pumping of the water when it has become a saturated solution.

Western Ontario possesses a large area of salt-bearing territory, roughly estimated at 2500 sq. miles. The immense tonnage available in this area is indicated by the fact that a borehole near Goderich, in Huron County, sunk to a depth of 1500 ft., traversed six beds of salt, ranging in thickness from 6 to 35 ft. At Windsor, in 1600 ft. of saline strata, four beds were encountered, one of which measured 250 ft. in thickness. The formation is Onondaga, of Silurian age. The mineral is extracted by forcing water down the boreholes and evaporating and purifying the effluent brine.

Twelve firms are engaged in the extraction and manufacture of saline products, the total output of salt in 1912 being 95,053 tons. Two firms are now producing soda and other alkaline products.

No account of the economic geology of the Dominion would be complete without a reference to the salt that abounds in the Devonian strata along the west side of Lake Winnipegosis. Salt springs are found in every direction through the district, and a small creek entering the lake north of Bell River is estimated to carry down 37 tons of salt per 24 hr.

It is not yet known whether the mineral exists in the form of brine or rock-salt beds, but the vastness of the source, indicated by the numerous salt springs, favors the latter theory. The high proportion of potassium chloride (up to 209 grains per gal.) in the brine points out the possibility of the occurrence of potash minerals in this region, and especially in connection with the heavy beds of gypsum which accompany the saline strata. The whole district is well worth careful examination and some drilling. Transportation facilities are very good.

Greece.—News has arrived at Salonica from Kilkitch confirming the importance of the mines of rock salt which have recently been discovered. The Department of Public Works has sent to Kilkitch an engineering expert to study the beds on the spot.

India.[1]—The salt business in India showed increases, both in quantity and value by 32,000 tons and £18,000 to 607,000 tons, valued at £584,000, and was mostly imported into Bengal and Burma. The chief countries from which salt is imported are the United Kingdom, Germany, Spain, Aden, Asiatic Turkey, and Egypt. The importation from Spain and Asiatic Turkey increased largely during 1913–1914 with a setback in the case of imports from the United Kingdom, Egypt and Aden, while those from Germany remained steady. English salt has declined from 198,000 tons in 1911–1912 to 152,000 tons in 1912–1913, the latter figure being reduced in 1913–1914 to approximately 137,000 tons, although the consumption of salt during 1913–1914 was 1,769,300 tons, or about the same figure as in 1912–1913.[1]

Philippines.—The manufacture of salt from sea water in the Philippine Islands is accomplished by the very crudest methods. The greater part of the salt made is produced by sun evaporation; a small proportion is made by artificial heat. The Chinese have introduced slightly improved methods. About 40,000,000 lb. of crude salt is produced annually. In the Mountain Province a small amount of poor grade salt is produced by evaporating the water from carbonated springs, but the supply falls far short of the demand, and the quality is of the poorest. About 20,000,000 lb. of salt is annually imported. Most of this comes from China. This is chiefly crude. About 1,000,000 lb. comes from the United States each year. This consists of the better grades of table salt. The United Kingdom sells the islands about 350,000 lb. yearly; Japan about 300,000 lb.; while Australasia and the other countries supply the rest—about 60,000 lb.[2]

Russia.—The Russian reserves of salt, whether in rock or brine, are in places abundant. Those principally worked are in the zone stretching from the district north of the Azof Sea to the district on the northwest of the Caspian Sea; the former including the important Bachmut and Slavyansk reserves, and the latter the rock-salt deposits of Illyetz Zaschtchitchi. But the salt production in Russia is not a rapidly progressing industry. Such increase as does take place is surprising in its insignificance. It is largely a syndicated business, which probably accounts for the decline that has taken place in the production of salt in the less important districts.[3]

[1] *Chem. Tr. Jour.* and *Chem. Eng.*, Jan. 30, 1915.
[2] J. F. Boomer, *Daily Cons. Tr. Rept.*, July 3, 1914.
[3] *Chem. Tr. Jour.* and *Chem. Eng.*, Jan. 30, 1915.

According to the Russian Mining Department there has been a serious decline in the production of salt in Russia over the past few years. Figures furnished in support of the statement show that this has occurred. In 1904 the production amounted to 112,500,000 poods; in 1908, 119,066,000 poods; in 1909, 136,955,000 poods; but in 1913 only 119,611,000 poods. It is pointed out that the decline observed during the past few years, reaching down to the figure named for 1913, is not in keeping either with the growing population of the country or its active economic development. Efforts have been made to get contractors to accept concessions for the production of salt under certain conditions, conformity with which would insure a larger output. The department, however, has been forced to the conclusion that other measures must be taken, to come into force in about 3 years' time, when the regulations under which salt deposits are now exploited will have elapsed.[1]

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[1] *Chem. Tr. Jour.*; *Chem. Eng.*, Feb. 20, 1915.

SULPHUR, PYRITE AND SULPHURIC ACID

By Samuel H. Salisbury, Jr.

As has been the case for several years past, the world's supply of ılphur has been obtained chiefly from Louisiana and Sicily, although ıcreasing amounts were supplied from other sources. On account of ıe European war the Sicilian sulphur trade has suffered considerably, ue not so much to decreased demand as to difficulties of shipment, nd reliable figures are lacking. However, it is safe to assume that even efore the war started there was a considerable decrease in Sicilian stocks ver the year 1913, due to scarcity of labor and other causes.

The imports of crude sulphur into the United States during 1914 were 2,810 long tons, valued at $409,537, an increase over 1913 of some 8000 ›ns, the figures for the year 1913 being 14,636 tons, valued at $278,056. 'his increase was mainly supplied from Japan by way of the Pacific 'oast and was not due to any activity of the Sicilian Consorzio. The ‹ports of crude sulphur continued to increase in 1914, being 98,153 ›ng tons, worth $1,807,334, as compared with 89,736 tons, valued at 1,599,761, in 1913 and 57,736 tons, valued at $1,076,414, in 1912. This ‹port trade shows no signs of having reached its limit and may be ‹pected to grow for some years, though in decreasing amounts.

In the United States, although the export trade showed a healthy ıcrease, the consumption remained around 800,000 long tons. On ccount of the disturbed conditions in Europe the demand was interrupted nd the domestic production was decreased to some extent, though a slight ıcrease in the stocks of the Union Sulphur Co. in Calcasieu Parish, ouisiana, is noted. While no report of the production in Texas has een obtainable, it is probable that the output was greater than in 1913.

Markets.—Prices in the United States were steady throughout 1914, uotations being $22 per ton at New York and $22.50 at by-ports. Local ›nditions at the Sicilian mines tend to force the price up a little, but ›cal prices are kept nearly uniform by the American output and will robably not rise appreciably for some time to come. The amount of ıpanese sulphur coming into Pacific ports was somewhat in excess of ıat which came in in 1913, but not in sufficient quantities to disturb ade conditions.

The value of the sulphur production of the United States for the year 914 has been placed at $5,500,000. The chief difficulty with regard

to sulphur is that it occurs abundantly in places where nobody wants it and is generally absent from those places where it is required. Since it commands only a comparatively low price, the production of sulphur-bearing material involves business considerations more than anything else. Consequently pyrite is imported from Spain to points on the Atlantic seaboard, since the railroad freight in this country, with additional handling charges, makes the domestic pyrite cost more than imported material. Sulphur from Sicily used to be imported into the United States in considerable quantities, but of recent years the Louisiana sulphur has been produced and sold so cheaply that Italian imports amounted to only 125 tons of sulphur in 1913. Two-thirds of the total sulphur imported comes from Japan, most of it entering at Portland and Hawaii, though some of it enters San Francisco in competition with the copper-bearing pyrite of California. The Hall process, in course of development at Coram, is likely to cause a change in the California situation, but can scarcely affect other points, for freights will not permit the California sulphur to compete with the Louisiana and Japan product at any great distance from its point of origin.[1]

The Louisiana producers are now "carrying the war into Africa," and competing with Italian sulphur on its own ground. The principal American company has established a distribution depot at Rotterdam and has chartered steamers for carrying its product. The Sicilian producers are rather dejected, as working costs there go up as the mines go down. Wages go higher because of the emigration of laborers to America, while the Italian government has restricted the granting of concessions. Some of the deposits have been worked out and corresponding new discoveries have not been made, so that there is every reason to believe that the Sicilian output will steadily decline. The increasing production of sulphuric acid by the copper smelters is also a factor in the sulphur situation, though not a disturbing one, for the smelters are commonly so situated that they can not compete to advantage with the present makers of acid on account of freight rates.

The marketed production of sulphur in the United States in 1913 was 311,590 long tons, valued at $5,479,849. As compared with the production of 1912, which was 303,472 long tons, valued at $5,256,422, this is an increase of 8118 long tons in quantity and of $223,427 in value. For the second year in the history of sulphur mining in the United States, exclusive of 1908, the production exceeded the 300,000 long ton mark. By production is meant actual sales of sulphur which enter and affect the market. The unsold sulphur stocked at the mines is not included. The output of Sicilian sulphur amounted to 351,752 metric tons (346,-

[1] *Min. Sci. Press*, July 18, 1914.

213 long tons) for the year ending July 31, 1913. It is interesting to note, therefore, that the United States is rapidly gaining on Sicily, which at the present time is the leading sulphur-producing country in the world. The production of sulphur in the United States in 1880 was 536 tons; in 1900, 3147 tons; in 1910, 255,534 tons; and in 1913, 311,590 tons.

SULPHUR IMPORTS AND EXPORTS OF THE UNITED STATES
(In tons of 2240 lb.)

Kind.	1909.		1910.		1911.		1912.		1913.		1914.	
	Amt.	Value.	Amt.	Value.	Amt.	Value.	Amt.	Value.	Amt.	Value.	Amt.	Value.
Imports:												
Crude.....	26,914	$458,954	28,647	$495,988	24,250	$436,725	26,885	$494,778	14,636	$278,056	22,810	$409,537
Flowers.....	770	23,084	912	30,180	3,891	83,491	1,310	39,129	5,899	115,574	621	17,214
Refined.....	966	26,021	985	25,869	986	24,906	1,665	40,933	1,234	29,091	1,800	47,568
Precipitated..	58	7,565	47	6,489	68	8,643	66	9,137	350	17,690	105	14,171
Total imports....	28,708	$515,624	30,544	$552,037	29,127	$545,122	29,860	$574,837	22,119	$440,411	25,336	$488,490
Exports.....	37,152	736,928	30,742	552,941	28,103	545,420	57,736	1076,414	89,221	1,559,761	98,153	1,807,334

CONSUMPTION OF SULPHUR IN THE UNITED STATES
(In tons of 2240 lb.)

Source.	1907.	1908.	1909.	1910.	1911.	1912.	1913.	1914.
Sulphur—Domestic production.	307,806	307,761	303,000	259,699	206,200	787,663	311,590	400,000
Imports.....	20,318	20,118	26,914	28,647	24,250	26,885	14,636	22,810
Total.....	328,124	327,879	329,914	288,346	230,450	814,548	326,226	422,810
Exports.....	35,925	27,894	37,152	30,742	28,103	57,736	89,221	98,153
Consumption.	292,199	299,985	292,762	257,604	202,347	756,812	237,005	324,627
(a) Sulphur contents....	286,355	293,985	286,906	252,452	198,300	741,676	232,265	317,978
Pyrites—Domestic production..	261,871	206,471	210,000	223,700	299,904	337,243	341,338	336,662
Imports.....	627,985	668,115	692,385	806,590	1,001,453	964,478	848,674	977,372
Total.....	889,856	874,587	902,385	1,030,290	1,301,357	1,292,213	1,190,012	1,314,034
Exports.....	.....	.....	.....	.....	.....	.....	.....	.....
Consumption.	889,856	874,587	902,385	1,030,290	1,262,540	1,292,213	1,190,012	1,314,034
(b) Sulphur in domestic....	115,223	90,847	92,400	98,428	131,958	148,387	150,189	148,131
(c) Sulphur in foreign.....	295,153	314,015	325,420	379,097	470,683	453,305	398,898	459,365
Total sulphur content....	410,376	404,862	417,820	477,525	602,641	601,692	549,087	607,496
Grand total sulphur consumption. (e)	(d)696,731	(d)698,847	704,726	729,977	800,941	1,343,368	781,352	925,474

(a) Includes crude and refined sulphur. Sulphur content of crude is computed at 98 per cent. (b) Computed at 44 per cent. (c) Computed at 47 per cent. (d) This figure is in excess of the true consumption as a large percentage of the domestic output of sulphur was stored. (e) The above totals are of course exclusive of by-product sulphur.

The table of consumption is retained, but the figures are only for comparison with previous years. Actual consumption can not be calculated because the stocks of sulphur are not known, and the imports of pyrite used for the sulphur content are probably low.

SULPHUR MINING IN THE UNITED STATES

Louisiana.—The principal producer in the United States, as heretofore, was the Union Sulphur Co., the production of which in 1914 was about 375,000 long tons. This is less than the production of 1913 by approximately 100,000 tons, the production being curtailed by reason of large stocks on hand and the decrease in exports due to the European war. Some of the largest producing wells ever brought in were pumped in 1914, and in consequence steaming operations were much reduced; only three wells were being pumped at the end of the year, as against four at the end of 1913.

The company increased its large stocks of sulphur at Sulphur, La., notwithstanding that it operated only one-half its steaming plants in 1914, this being due to the fact that disturbed conditions in Europe interrupted the demand there and the shipping conditions helped to demoralize the market. At its four European distributing stations, viz., Rotterdam, Hamburg, Marseilles, and Cette, the company had fair stocks at the end of 1914, though hardly sufficient to supply the demands that arise at this time. The company's refineries at Cette and Marseilles were the subject of much suspicion in France at the outbreak of the war, owing to the fact that sulphur is contraband of war and to the fact that the local managing officials were Germans. The Germans fled and the plants were threatened with seizure by the French government; however, after some negotiations this was averted by satisfactory representation of American ownership being made.[1]

A description of the Louisiana sulphur deposits is given in MINERAL INDUSTRY, **18**, 644. The Frasch process for removing sulphur as applied in the Louisiana field is described in MINERAL INDUSTRY, **5**, 514.

Texas.—What is probably the greatest surface deposit of sulphur in the United States lies in southwestern Texas, chiefly in Culberson and Reeves Counties. The sulphur occurs in a disseminated condition in the heavy gypsum deposits of that region. The zone covers several hundred square miles.

The gypsum in the valley from Toyale north to the Delaware hills, a distance of perhaps 75 miles, contains sulphur which apparently was taken into solution and not deposited until the sea went dry. But where the sulphur is in sufficient quantities for commercial consideration, it is found in a single stratum or deposit which has the appearance of having been thrown down immediately upon the injection of the sulphurous spring waters into the sea water already saturated with gypsum. The

[1] *Eng. Min. Jour.*, Jan. 9, 1915.

latter is intermingled with the sulphur in these deposits, the sulphur content ranging from 20 to 30 per cent.

During the past 15 years these deposits have attracted considerable attention, but no really serious effort has ever been made to put them upon a commercial basis. Some years ago, however, a company said to have been composed of Italians attempted to refine sulphur at Maverick Springs and on the Cooksy ranch, at a point 7 miles north of Rustler Springs. From appearances, operations ceased very suddenly. The retorts at Maverick Springs are still filled with a partly refined charge, and most of the equipment is still on the ground. From this abandoned plant it is apparent that these embryonic developers had little conception of the work in hand. They attempted to refine sulphur in steel retorts in a country where there is no water fit for boiler use within a radius of 20 miles.

The question of tonnage does not enter into this proposition. The problem is to work a great number of deposits from 15 to 50 miles from railroad transportation in a desert land where no good water exists. While the fact has not been definitely proved, it is probable that there is no single deposit of sufficient tonnage to supply a large plant for any great length of time. To be a success the deposits must be worked on the "steam-shovel basis." It will take a man of steam-shovel proportions to do the job.[1]

Construction work on the improvements at the Freeport Sulphur Co.'s mines at Freeport, Tex., now being installed, for the purpose of increasing the sulphur production at Texas' only sulphur field now being developed, has shown marked and rapid progress during the past month.

The concrete foundations for the 8000-h.p. battery of boilers, part of the new mining unit to be used for the production of superheated water—the basis of sulphur mining—have been completed. Work on the foundations for the pumps and other machinery comprising the new plant are well under way and rapidly nearing completion.

Six hundred tons of machinery, boilers, pumps, and structural iron used in the new fireproof plant has arrived from New York on the Seaboard & Gulf Steamship Co.'s steamer Kennebec, and was being moved by rail to the mines. Installation of the boilers and pumps and the erection of the building to house the plant is under way. When completed this will make the second superheated water unit installed, and is in line with the fixed policy of the company to build one unit after another as fast as is practicable with systematic and economical mining practices.

The doubling of the plant, whereby an increased supply of super-

[1] C. M. Becker, *Min. Sci. Press*, Aug. 22, 1914.

heated water will be forced into the sulphur formation to melt out the mineral so it may be pumped to the surface, will actually mean more than doubling the output of the mined product, as it has been found by past experience that an added unit will considerably increase the production beyond the double production logically expected.

A steady shipment of sulphur from the Freeport mines has been going by rail to the eastern and northern markets ever since the first of the year, and the first load of sulphur shipped through Freeport from the Freeport Sulphur Co.'s mines left on April 8 on the Seaboard & Gulf Steamship Co.'s steamer *Honduras*. It was also the first heavy tonnage of outbound cargo that has left the mouth of the Brazos River in nearly 20 years.

Loading of the ship started on April 5 and was finished on the evening of the 7th. Sixty-six cars of sulphur, averaging approximately 33 tons to the car, were used in loading the *Honduras* by a newly constructed sulphur conveyor located at the east end of the steamship company's pier on the ship channel. This conveyor on its first test showed that it could handle close to 60 tons an hour, and when slight mechanical changes are made to perfect it, this device will be able to even better this rate of delivery.

Part of the cargo on the *Honduras* was consigned to Baltimore and the balance to New York.

This marks the beginning of a new era of outbound tonnage from Freeport, which, until the present New York financial interests of prominence took hold of it for development, had lain dormant for nearly two decades. The basis for this immediate deep-water tonnage will be the large future cargoes of sulphur from the output of the Freeport Sulphur Co.'s mines at Bryan Heights.[1]

Wyoming.—A 160-acre sulphur tract a short distance north of Cody, Wyoming, is being developed and equipped by Denver parties. There is being constructed a 50-ton refinery as the first unit. Crude sulphur as quarried will be hauled 2 miles to the plant by rail and there dumped into a hopper which, in turn, will deliver into small steel cars having perforated sides and bottoms. These cars will be run into closed retorts where heat will melt the sulphur and permit it to flow from the gangue and collect in a drain leading to collecting vats where it will solidify.

Foreign Sulphur Industry

Russia.—Among the minerals to which attention is now being called in Central Asia is sulphur, which is found at Kara-kum, about 150 miles

[1] *Min. Eng. World*, April 25, 1914.

north of Aschabad. It appears in the form of conical hills of 700 ft. and sometimes higher. These accumulations consist largely of sand bound together by sulphur of a purity equal to 60–90 per cent., and even the poorer qualities are considered of good commercial value. The difficulty of exploiting these deposits, of course, is the old one in Russia, namely that of fuel and water, besides defective ways of communication. The deposits are considered by Russian technical men as very rich as well as extensive, and in case of need can be brought the necessary distance to make superphosphates with the phosphorites that are so plentiful in Eastern European Russia. The quantities are put at the lowest estimate at tens of millions of poods, and are sufficient to form the basis of a considerable superphosphate industry, always under the disadvantages named above.[1]

TOTAL EXPORTS OF SULPHUR FROM SICILY, 1906–1914
(In metric tons)

Country.	1906.(*d*)	1907.(*d*)	1908.(*d*)	1909.(*d*)	1910.(*d*)	1911.(*d*)	1912.(*d*)	1913.(*d*)	1914.(*d*)
Austria	24,703	26,390	22,086	26,560	29,601	34,136	38,362	36,335	25,306
Belgium	8,538	8,066	8,746	16,377	14,305	11,771	10,723	13,321	5,975
France	71,021	59,868	96,448	90,239	93,229	114,868	104,109	21,582	60,773
Germany	40,113	35,059	30,229	28,538	30,225	28,664	32,286	31,042	18,826
Greece and Turkey	25,136	27,969	24,838	16,309	21,435	24,933	15,436	20,112	20,746
Holland	10,037	14,951	9,812	8,708	9,731	10,549	14,019	8,976	8,080
Italy	81,329	57,743	60,134	49,692	61,269	72,959	84,952	85,740	97,170
Portugal, Spain	15,968	13,328	17,586	21,036	18,758	25,121	21,314	21,445	17,604
Scandinavia (*c*)	21,605	23,415	30,366	19,905	20,354	29,741	35,111	28,108	25,294
Russia	18,174	21,244	14,068	18,584	25,866	23,485	25,563	25,891	21,290
United Kingdom	18,687	17,929	20,597	19,860	19,074	19,936	19,830	16,052	12,991
United States	37,725	4,047	9,654	14,706	12,205	8,482	2,856	1,028	1,406
Other countries(*b*)	28,591	31,942	30,509	33,999	36,935	49,181	42,731	54,185	22,883
Totals	401,627	341,951	375,037	364,513	393,987	453,826	447,292	414,717	338,344
Stock in Sicily, Dec. 31	523,586	594,459	616,419	647,880	640,711	551,442	450,917	376,365	369,001

(*a*) Reported by Emil Fog & Sons, Messina. (*b*) Mainly South Africa, Northern Africa, Asib, Australia, and the East Indies. (*c*) Including Norway, Sweden and Denmark. (*d*) Reported by Parsons & Petit, New York. (*e*) Includes Canada.

Japan.—The output of sulphur produced in the Hokkaido has been showing an increasing tendency since January, 1914. The exports of sulphur to Australia had a check on the outbreak of war, but the consumers in North America who had heretofore been getting their supplies from Italy were now constrained to buy of Japan, thus causing increased activity in the export trade of this commodity. As a result the working of the sulphur mines in the Hokkaido became more active, the output of the principal mines there amounting to 10,413,729 lb. during the month of October. The total for the first 10 months of the year amounted to

[1] *Chem. Tr. Jour.*, Nov. 28, 1914.

85,148,235 lb., or an increase of about 27,000,000 lb. over the figures for the similar period of 1913.[1]

At first the sulphur market appeared to be unaffected by the war; exports continued plentiful and prices firm. The war, however, has embarrassed dealers indirectly. It has sent up the price of wheat, and through this wheat can not be shipped profitably any longer to the Japanese market. Hence there is less hold space available on the return journey, and American orders for sulphur have had to be refused through inability to ship. The home demand is also somewhat in defect, and it is estimated that there are now over 10,000 tons of sulphur congesting the market. About 8000 tons of this is held in the Hokkaido by the syndicate of which the Mitsui firm is at the head. Holders of stocks in Hakodate have begun to sell for whatever they can get, and Osaka merchants are ready to sell the best Hokkaido sulphur at 30 yen ($14.94) per ton for cash payment. Unless there is an improvement the sulphur mines in remote parts, or with a small capital, will have to close down. Bar sulphur is in good demand for special purposes, and its price is maintained.[2]

New Zealand.—One of the largest and most remarkable sulphur deposits in the world is situated on White Island, which is a volcanic mountain that belongs to New Zealand. The first efforts to utilise this sulphur in a commercial way were made in 1886. At that time the island was so isolated that the exploiters found it impossible to keep a working force. This, together with a lack of transportation facilities, caused the industry to be abandoned. In 1912 interest in the possibilities of the industry was revived. What is known as the New Zealand Sulphur Co. was organized with a capital working stock of $125,000 and a reserve capital of $100,000 for the purpose of acquiring and operating the deposit. Since then a well-equipped permanent camp has been established, retorts for the refining of the sulphur erected, and other facilities installed for handling the product. The output of the plant is now about 1000 tons per month, and this is to be greatly increased. Excellent arrangements are in effect for the transportation of the product to the different ports of New Zealand, Australia, the Straits Settlements, and islands in the Pacific Ocean. It takes about 30,000 tons of sulphur annually to supply the Australian market, and it is planned that all of this shall come from the deposit on White Island. The annual consumption of sulphur in New Zealand is about 3000 tons, and it is increasing.[3]

[1] Ext., Tokyo Koshinjo's Daily Report of Dec. 25, 1914, by Consul General George H. Scidmore Yokohama, Japan, *Daily Cons. Tr. Rept.*

[2] From *Japan Chronicle* of Dec. 8, 1914, forwarded by Consul General George H. Scidmore, Yokohama, *Daily Cons. Tr. Rept.*

[3] *Min. Sci. Press*, Dec. 12, 1914.

WORLD'S PRODUCTION OF SULPHUR (*a*)
(In metric tons)

Year.	Austria. (*b*) (*e*)	Chile.	France. (*b*)	Germany.	Greece.	Italy. (*b*)	Japan.	Spain.	United States.	Total.
1897.....	642	664	10,723	2,317	358	496,658	12,013	(*b*)3,500	1,717	528,592
1898.....	589	1,256	9,818	1,954	135	502,351	10,339	3,100	2,770	532,312
1899.....	671	989	11,744	1,663	1,150	563,697	10,241	1,100	1,590	592,290
1900.....	985	2,472	11,551	1,445	891	544,119	14,439	750	4,630	581,282
1901.....	5,048	2,516	6,836	963	2,336	563,096	16,548	610	6,977	604,930
1902.....	3,826	2,636	8,021	487	1,391	510,333	18,287	450	7,565	552,996
1903.....	4,610	3,560	7,375	219	1,266	553,751	22,914	1,680	35,660	631,035
1904.....	6,431	3,594	5,447	209	1,225	527,563	25,587	605	196,588	767,249
1905.....	8,542	3,470	4,637	205	1,126	568,927	24,652	610	218,440	830,609
1906.....	15,258	4,598	2,713	178	(*d*)1,000	499,814	27,589	700	298,704	845,956
1907.....	24,199	2,905	2,000	176	(*d*)1,000	426,972	33,329	3,612	312,731	801,911
1908.....	17,429	2,705	2,189	811	(*d*)1,000	445,312	33,419	13,872	312,700	829,437
1909.....	12,856	4,508	2,900	1,185	(*d*)1,000	435,060	36,317	21,750	303,000	817,608
1910.....	15,976	3,823	2,641	1,272	.....	430,360	43,848	30,113	259,699	787,732
1911.....	15,856	4,451	1,200	1,251	174	414,671	52,064	40,662	246,300	776,629
1912.....	14,979	4,431	1,000	(*c*)	2,016	357,547	55,005	42,344	308,530	785,852
1913.....	10,561	.....	659	.....	.....	349,602	59,481	62,653	316,783	.....

(*a*) From the official reports of the respective governments. The sulphur recovered as a by-product by the Chance-Claus process in the United Kingdom, amounting to between 20,000 and 30,000 long tons annually, is not included. (*b*) Crude mineral; limestone impregnated with sulphur. (*c*) Not yet reported. (*d*) Estimated. (*e*) Includes such production from Hungary.

PYRITE

The production of pyrite in 1914, while declining in several states, was well maintained on the whole by the restriction of importation from Europe, and several companies had the best year in their history. The recession in the fertilizer business in the latter half of 1914 would have had a more serious effect on the mining of pyrite had not the rise of shipping rates reduced the importations from Spain, Portugal, and Norway to about one-half the quantity imported in the previous year.

Virginia continued to lead in pyrite production, the largest individual operator being the Arminius Chemical Co., with an output of about 53,000 long tons; the Sulphur Mining & Railroad Co. also operated its property at Mineral, though at somewhat reduced capacity; the Boyd Smith mine, situated between these two properties, made no production in 1914, but the owners expect to place the mine on a producing basis as soon as normal conditions prevail. The Cabin Branch Mining Co., at Dumfries, made its usual output, and the pyrrhotite mines in the southwestern part of the state were also operated.

In New York the principal producer, the St. Lawrence Pyrites Co., at De Kalb Junction, made the greatest output in its history, shipping out 56,000 tons of concentrate and 2000 tons of crude ore; the mill ran throughout the year with the exception of about 3 weeks, during which time extraordinary repairs were made.

In California, which stands third among the states producing pyrite, the output is largely from cupriferous pyrite from Keswick and the market was not benefited by the restriction of European importations,

as was the case in the Appalachian states. In the Middle States, aside from Wisconsin, which produces marcasite, the pyrite production is mainly a by-product of coal mining and fluctuates with that production and the market demands. Arkansas made a small production of crude ore, which was used in nearby plants. In Georgia the production remained small.

The Northern Pyrites Co., at Northpines, Ont., had a satisfactory year, shipping its concentrates to Lake and Mississippi Valley plants, though some of the output also reaches Eastern plants. The company increased its output in 1914, and changed from wood to coal fuel.[1]

The production of pyrite in the United States in 1914, according to the U. S. Geological Survey, was 336,662 long tons, valued at $1,283,346. In 1913 the production was 341,338 long tons, valued at $1,286,084. There was a decrease, therefore, in 1914 of 4676 long tons in quantity, or slightly more than 1 per cent., and of $2738 in value, or but one-fifth of 1 per cent.

Virginia is the leading state in both production and value. The output of this state diminished slightly in 1914, as compared with 1913. The output in California showed a slight gain. There was a substantial gain in the production in New York which, though ranking third among the states in production, stands second in value. In Illinois, where pyrite is a by-product obtained in connection with coal mining, the output more than doubled, compared with 1913. In Wisconsin there was a decreased production. In Georgia there was a slight increase. In both Ohio and Missouri there was a decline in production, and in Indiana where, as in Illinois and Ohio, the pyrite is obtained in connection with coal mining, there was a slight increase, as compared with 1913.

PRODUCTION, IMPORTS AND CONSUMPTION OF PYRITE IN THE UNITED STATES (a)
(In tons of 2240 lb.)

Year.	Production.		Imports. (b)		Consumption.	
1899	178,408	$583,323	310,008	$1,074,855	488,416	$1,658,178
1900	201,317	684,478	322,484	1,055,121	523,801	1,739,599
1901	234,825	1,024,449	403,706	1,415,149	638,531	2,439,598
1902	228,198	971,796	440,363	1,650,852	668,561	1,622,648
1903	199,387	787,579	425,989	1,628,600	625,376	2,416,179
1904	173,221	669,124	413,585	1,533,564	586,806	2,202,688
1905	224,980	752,936	515,722	1,780,800	740,702	2,533,736
1906	225,045	767,866	597,347	2,138,746	822,392	2,906,612
1907	261,871	851,346	656,477	2,637,485	918,348	3,488,831
1908	206,471	744,463	668,115	2,624,339	874,586	3,368,802
1909	210,000	756,814	692,385	2,428,638	902,385	3,185,452
1910	223,700	830,150	806,590	2,773,627	1,030,290	3,603,777
1911	299,904	1,150,597	1,001,944	3,788,632	1,301,848	4,939,229
1912	350,928	1,334,259	964,478	3,860,738	1,315,406	5,194,997
1913	341,338	1,286,284	850,592	3,611,136	1,192,930	4,897,421
1914	336,662	1,283,346	1,026,617	4,797,326	1,363,279	6,080,672

(a) These statistics do not include the auriferous pyrite used for the manufacture of sulphuric acid in Colorado. (b) Net imports, less re-exports of 3060 tons in 1902 and 1330 tons in 1903. U. S. Geological Survey.

[1] *Eng. Min. Jour.*, Jan. 16, 1915.

The imports of pyrite for consumption during the calendar year 1914 were 1,026,617 long tons, valued at $4,797,326. These figures show a notable increase compared with the imports of 1913, which were 850,592 long tons, valued at $3,611,137. The increase in imports in 1914 amounted to 176,025 long tons, and in value to $1,186,189.

As has been the case heretofore, only about one-fourth of the total consumption of pyrite in the United States is supplied by domestic producers. The total consumption of pyrite is shown in the table.

Pyrite Mining in the United States

Although the great sulphuric acid industry of this country depends almost entirely upon pyrite as its source of sulphur, less than one-half of the total amount of pyrite consumed is produced at home, practically all the rest being imported from Spain. Even though we are the possessors of probably inexhaustible supplies of sulphur, the turning of the sulphuric acid manufacturers to sulphur as a raw material for the manufacture of their product is not to be expected, because sulphur can not compete with pyrite while selling at over $7 per ton and the cost of converting over pyrite burners in existing plants would be prohibitive.

Most of the pyrite produced in the world is for its metal value rather than for its sulphur content, so that it is even a question whether at $7 a ton sulphur could compete with pyrite for the manufacture of sulphuric acid.

Nearly half the output of American pyrites is from the South, the principal producing states being Virginia and Georgia. Other considerable deposits of pyrite ores have been reported in various parts of the South and further investigation should be made as to the feasibility of developing, on a large scale, the deposits of our own pyrite to lessen our dependence upon Spain.

The principal pyrite-producing states, in order of their tonnage, are Virginia, California, New York, and Georgia.

In Virginia the producing companies are the Arminius Chemical Co., the Sulphur Mining and Railroad Co., the Boyd Smith Mine, and the Cabin Branch Mining Co. These ores average about 48 per cent. of available sulphur, and in addition to this pyrite there is mined in the southwestern part of the state some pyrrhotite. During 1914 the Arminius Chemical Co. produced in the neighborhood of 53,000 long tons of ore. Smaller amounts were produced by the other companies, with the exception of the Boyd Smith Mine which produced none at all.

The amount of pyrite produced in Virginia, inclusive of pyrrhotite, for the past several years is as follows:

Year.	Long Tons.	Value.	Average Price per Ton.
1908	116,340	$435,522	$3.74
1909	114,176	423,283	3.71
1910	140,106	525,437	3.75
1911	150,800	558,494	3.70
1912	162,487	621,219	3.82
1913	148,259	587,041	3.96

In New York state the St. Lawrence Pyrite Co. produced during the year 1914 about 56,000 tons of concentrates and 2000 tons of crude ore. The mines operated by this company are described in MINERAL INDUSTRY, 22, 701.

In California most of the pyrite is produced for its metal content, but in addition from 70,000 to 80,000 tons is mined for the sulphur content alone, and this is used in the manufacture of sulphuric acid. This pyrite competes on the Pacific Coast with the Japanese sulphur. About the normal output, around 75,000 tons, was obtained during the past year.

California's output by counties for the past few years is as follows:

County.	1912.		1913.	
	Short Tons.	Value.	Short Tons.	Value.
Alameda	7,267	$29,068	6,029	$24,123
Shasta	62,605	174,402	72,971	194,409
Total	69,872	$203,470	79,000	$218,357

In Georgia only two producers mined pyrite, these being the mines at Villa Rica, 30 miles west of Atlanta and the mine of the Sulphur Mining and Railroad Co. The output of this state has been increasing for the past few years, the output for 1913 being nearly double that in 1912, while last year's output is still somewhat greater than that of 1913.

The other states producing small amounts of pyrite are: Wisconsin, Illinois, Indiana, Massachusetts, Michigan, and Missouri. Most of the output from these states is obtained as a by-product in coal mining and no important deposits have been discovered. The total output of all these will probably not exceed 25,000 tons.

The following table shows the world's production of pyrite for the past several years:

FOREIGN PYRITE INDUSTRY

Canada.—For the manufacture of sulphuric acid there are immense quantities of pyrite and pyrrhotite scattered through eastern Canada.

WORLD'S PRODUCTION OF PYRITE
(In metric tons)

Year.	Belgium.	Bosnia.	Canada.	England.	France.	Germany.	Hungary.	Italy. (a)
1899	283	.....	25,112	12,426	318,832	144,623	79,519	76,538
1900	400	1,700	36,308	12,484	305,073	169,447	87,000	71,616
1901	560	4,570	31,982	10,405	307,447	157,433	93,907	89,376
1902	710	5,170	32,304	9,315	318,235	165,225	106,490	93,177
1903	720	6,589	30,822	9,794	322,118	170,867	96,619	101,455
1904	1,075	10,421	29,980	10,452	271,544	174,782	97,148	112,004
1905	976	19,045	29,713	12,381	267,114	185,368	106,848	117,667
1906	908	13,474	35,927	11,318	265,261	196,971	112,623	122,364
1907	397	3,671	35,494	10,357	283,000	196,320	99,503	126,925
1908	357	5,000	42,934	9,599	284,717	219,455	95,824	131,721
1909	214	(b)	58,645	8,564	273,221	198,688	98,971	149,084
1910	213	571	48,871	10,393	250,432	215,708	92,464	165,688
1911	122	3,118	74,978	10,276	277,900	217,459	96,754	165,273
1912	148	6,216	73,944	10,691	282,202	242,121	103,809	277,585
1913	268	7,701	207,532	11,611	311,167	(g)228,405	106,629	317,334

Year.	Japan.	Newfoundland.	Norway. (c)	Portugal. (c)	Russia.	Spain.	Sweden.	United States.	Total.
1899	8,376	26,154	95,636	347,234	23,250	107,386	150	181,263	1,446,782
1900	16,166	*Nil*	98,945	402,870	23,154	34,638	179	204,538	1,464,512
1901	17,589	7,532	101,894	443,397	30,732	33,953	*Nil*	238,582	1,568,999
1902	18,580	26,000	121,247	413,714	26,465	145,173	*Nil*	231,849	1,713,654
1903	16,149	42,674	129,939	376,177	22,780	155,739	7,793	202,577	1,692,812
1904	24,886	61,166	133,603	383,581	31,667	161,841	15,957	175,992	1,696,099
1905	25,569	51,534	162,012	352,479	30,689	179,079	20,762	228,580	1,789,816
1906	36,038	28,583	197,886	350,746	20,660	189,243	21,827	228,646	1,832,475
1907	56,166	28,000	236,038	241,771	18,316	225,830	27,000	266,061	1,854,849
1908	33,867	(e)35,000	269,129	81,417	56,345	263,457	29,569	209,774	1,768,365
1909	27,066	*Nil*	282,606	284,735	46,078	236,000	16,104	213,371	(e)1,730,000
1910	78,418	*Nil*	322,000	312,906	55,980	294,184	25,445	227,280	1,826,854
1911	73,879	2,500	(e)350,000	282,773	113,054	344,879	30,096	304,974	.....
1912	74,929	*Nil*	469,326	(f)601,443	123,990	421,070	31,835	356,707	.....
1913	114,589	.....	441,291	(f)391,083	.....	926,913	34,319	347,027	.....

(a) Cupriferous in part. (b) Reports not yet available. (c) Both iron and copper pyrites. (e) Estimated. (f) Includes 120,148 tons copper iron pyrite in 1912 and 13,550 tons in 1913. (g) Prussia alone.

The ordinary di-sulphide is mined in Hastings County and in the northern part of Ontario. Northern Ontario has large areas that could turn out a heavy tonnage of this mineral, and the eastern townships of the province of Quebec have been producers of sulphuric acid since 1870. There is no scarcity of acid-making material in the Dominion, and no attempt has been made by any of the copper-smelting works to condense their fumes.[2]

At Big Vermilion Lake, in the Winnipeg consular district, American interests are engaged in mining pyrite, all of the output going to the United States. Two shafts are in use on the property, the first being equipped with a 41-in. single-drum Ledgerwood hoist, the other having a 30-h.p., Flory double-cylinder friction hoist and Stephenson-Adamson automatic mine skip.

At No. 1 shaft the power plant consists of three 100-h,p. 66 by 16 Jenckes horizontal tubular boilers, and air is supplied by a Canadian-Rand cross-compound Corliss compressor of 1000 cu. ft. capacity, and

[1] A. W. G. Wilson, *Can. Min. Jour.*, April 15, 1913.
[2] *Min. Jour.*, Feb. 13, 1915.

one half-duplex Allis-Chalmers-Bullock air compressor, class G. C. There is also a high-pressure type A, 4¾ by 4½ American blower, vertical engine, and a 6-kw. Bullock generator. The mine is also supplied with feed, heater, supply, and fire pumps.

Five Austin gyratory crushers are used. Bucket elevators convey the crushed ore to the bins over an aerial tramway, power being supplied by a 16 by 18 Regal automatic engine. A new aerial tramway has recently been installed by an American company, with a capacity of 300 to 350 tons each 10 hr. This rope transmission tramway is 8000 ft. long.[1]

The Pyrite Mines on Pilley's Island, also in Notre Dame Bay, at one time worked on a large scale by American operators, are now closed and full of water.[2]

Russia.—The production of pyrite in the Urals has increased decidedly in the last few years. This increase began to be important in the year 1910; the output in 1911 was 6,801,921 poods, and increased to 7,569,614 poods in 1912, instead of the two or three million poods formerly registered as the annual production in the Urals. The natural boundary for the distribution of Ural pyrite toward the west and south has hitherto been considered to be the Moscow district, on account of the heavy expense involved in transporting the ore. It is now understood that efforts are being made to place Ural pyrite in the southern towns of Russia near the Black Sea, Odessa, for example. These transactions were consummated at low prices and, in view of the geographical position of the districts named, great hopes are not expressed of these tentative efforts developing into an important business. It has been calculated that the cost of Ural pyrite at the mine mouth was 3½ to 6 copecks per pood, from ($1.10 to $1.90 per long ton). There is a tendency on the part of the chemical works to establish plants in the vicinity of the mines for the purpose of making acid and various other chemicals depending on this raw material.[3]

Spain.—The province of Huelva, as is well known, produces annually nearly 4,000,000 tons of pyrite, most of it for export, the principal value of which is represented by its sulphur contents, although the greater part contains also copper in quantity sufficient to materially enchance its value. Of the total export, about one million tons goes to America, more than half a million each to England and Holland (part of the latter for trans-shipment up the Rhine into Germany), and about a million tons is divided between Germany, France, and Belgium, more than half a million being for the first mentioned country. In consequence of the war, shipments to France, Belgium, Germany, and Holland have been sus-

[1] *Daily Cons. Tr. Rept.*
[2] *Eng.Min. Jour.*, Jan. 2, 1915.
[3] *Eng. Min. Jour.*, March 21, 1914.

pended altogether, those to America have fallen off to less than one-half of the normal amount, and even the small shipments to neutral countries have diminished. As a result, the mines of the province as a whole, not having any outlet for their product, have had to cease operations. San Miguel, Pena del Hierro, San Platon, La Joya, San Telmo, Castillo de las Guardas, and several smaller mines are shut down completely. Rio Tinto is working half time or less in most departments, the smelting plant and the South Lode mine being shut down completely. Esperanza, the French Société de Pyrites, and the United Alkali Co.'s mines are working sometimes less than half time. The only two companies that are still working full time are the Tharsis and the Huelva Copper.[1]

The pyrite sulphur ores are in part classified as copper ores in the reports of the government, so that it is impossible to make an estimate from these reports.

The official figures of the exportations of pyrite and of minerals containing less than 2.5 per cent. of copper are as follows for the last 3 years:

1911	about 2,800,000 tons.
1912	about 3,040,000 tons.
1913	about 2,975,000 tons.

It can be deduced from these figures that the diminution in the exportation during 1913 is due to the strikes that have taken place in the different centers of production, and in particular, at Rio Tinto.

For some time past certain exporters have been demanding payment for the iron content of the pyrite.

Technology

Hall Desulphurizing Process.—The aim of the Hall process is to eliminate sulphur in the elemental form from sulphide ores or mattes, thus preventing the escape of SO_2 and recovering the sulphur itself. By the introduction of water vapor into the distilling chamber, from which air is almost entirely excluded, the sulphide is supposed to yield its sulphur into combination with hydrogen, either from the water or from the fuel gas or oil, thus leaving an oxide of the metal and generating H_2S. Thereafter, in theory at least, the H_2S releases elemental sulphur and returns the hydrogen to a combination with the oxygen present in the chamber. The form of the metallic oxide varies in the successive reactions. It is certain, however, that elemental sulphur is formed and SO_2 is almost entirely absent. The importance of this expected achievement is apparent as a solution of the sulphur fume problem in smelting, not to mention the probable cheapening of sulphur.

[1] *Min. Mag.*, Nov., 1914.

Results of the operation of this process, using an 18-ft. McDougall furnace at the Coram Smelter, may be stated as follows: The ore used was crushed to half-inch and smaller and screen analysis on the calcines showed that the sulphur elimination from the 10-mesh material improved. However, it was found extremely difficult to roast the ore down to the 5 per cent. point which was aimed at.

Careful analyses were made of the atmosphere existing in every hearth of the furnace and in the flue leading from it. The first 2 weeks were devoted to tests in an atmosphere containing 1 per cent. or less of free oxygen and rather generous percentages of CO, in other words, using a highly reducing atmosphere throughout. Under these conditions the calcination was no better than to about 10 to 12 per cent. of sulphur in the 10-mesh material. The larger pieces of ore as they came from the furnace contained as high as 26 per cent. of sulphur, the original averaging roughly 40 per cent. sulphur. The escaping gases contained hardly a trace of SO_2. Finally conditions were arrived at so that ore was fed at the rate of 24 tons per 24 hr. During this period the sulphur remaining in the 10-mesh calcines averaged 5.5 per cent. The sulphur remaining in the total sample of half-inch material, coarse and fine together, averaged 8.8 per cent. Oil consumption was 22 gal. per ton of ore, the oil being a very cheap material carrying 25 per cent. of asphalt and of about 23° B. gravity. The SO_2 in the fumes escaping from the furnace for a period of 2 weeks was a trifle over 0.3 per cent. Labor required is practically the same as for ordinary McDougall roasting; the more furnaces and larger tonnage treated the lower the labor cost per ton, since it takes just as many men to tend and feed one furnace as four. The best results, maintained for 24 to 48 hr., toward the end of the 2-week period were as follows: oil consumption, 16 to 17 gal. per ton of ore; 10-mesh calcines, 5.3 per cent. sulphur, though for 2 or 3 days the calcines ran between 2.8 and 3.6 per cent. sulphur; SO_2 frequently as low as 0.06 per cent.

It is thought that with 10-mesh ore, and with arrangements for more frequent rabbling, and for keeping the ore in certain portions of the furnace a greater length of time than the present conventional practice provides, the following results can be maintained without difficulty: in an 18-ft. McDougall furnace 40 tons of 10-mesh ore can be treated daily, with 500 gal. of oil, roasting it down to 5 per cent. sulphur, and controlling the SO_2 fumes so that they shall never exceed 0.3 per cent. and probably average 0.15 per cent. or less.

As to the chemical reactions—in the upper portion of the furnace one-half the sulphur s distilled by heat alone. The very lowest portion of the furnace, say one-third of the hearth area, is devoted to the oxidation

of iron, copper, and remaining sulphur, by a free admission of air. In the middle third of the furnace a strongly reducing atmosphere and rather high temperature, say 1500° F., are maintained, and it is in this central portion of the furnace that the SO_2 formed below is broken and reduced to elemental sulphur. It is an undeniable fact that some H_2S is formed in the upper regions, and it is equally undeniable that H_2S will react upon SO_2 under certain conditions, forming water and sulphur, but it has not been proved that the H_2S—SO_2 reaction is the controlling feature in the reduction of SO_2. When a too heavily reducing atmosphere is permitted in the presence of liberated elemental sulphur and steam, certain undetermined organic sulphides are formed which seriously interfere with the production of sulphur. There seem to be two ways of preventing this interference: First, avoiding too great an excess of fuel; second, a quick drop in the temperature at the point where these excess oil vapors and free sulphur exist. Naturally, the former is the more economical way, but both have proved feasible.

The sulphur may be recovered from the gases or allowed to go to waste. At Coram a Feld gas washer was tried but was not a success because it rapidly became clogged, but it is probable that the fumes could be scrubbed in a tower filled with baffle boards over which flows a calcium chloride solution, or that the fume could be cleared by means of a Cottrell precipitator.[1]

Sulphur Dioxide

The principal sources of sulphur dioxide, SO_2, are ore-roasting or calcination gases, pure sulphur, pyrite, and sulphide of zinc. It is also produced from used-up gas-cleaning materials, from by-products of the Leblanc process (which is now of little importance, as this process is not modern), and finally from sulphates, particularly from hydrated sulphate of lime. The composition of the gases containing SO_2 differ very much. Those produced directly from sulphur contain 11.23 per cent. by volume of SO_2; those from pyrite, 8.59 per cent., and those from sulphide of zinc, 8.1 per cent.

The methods of concentrating and liquefying sulphur dioxide are manifold. All of them are akin to the process of Schroeder and Hoenisch. All aim at absorption through water, after which the solution is heated so that SO_2 is separated; it is then condensed by compression or refrigeration.

Sulphur dioxide is sold in containers of wrought iron, cast iron, or cast steel, 2.1 meters (6.8897 ft.) in length, and tested officially at a pressure of 30 atmospheres. It is used in medicine (Hartmann, D. R. P.

[1] Abstracted from *Min. Sci.*, Nov., 1914.

89436); for the cleaning of clays (Raynand, D. R. P. 107502); for the separation of copper (L. Jumann, D. R. P. 214811). As a liquid it is used in solutions in the conservation of dried fruits, in the production of wine, for the bleaching of flour and textiles, as a disinfectant, in the manufacture of sugar, in the manufacture of glue and gelatin, in the production of sulphite-cellulose, and in refrigeration.[1]

The placing of sulphur upon the list of articles that are contraband of war has placed Scandinavian chemical pulp producers in a peculiar position. The lack of sulphur has seriously impeded the industry. The question of alternative means of producing sulphurous acid in some other way than by burning pure sulphur is answered by the claim that by the use of pyrite there can be effected a saving of nearly $12.10 per hundred kilos of sulphur. Pyrite containing 45 per cent. of sulphur can be utilized quite easily, and even those pyrites that have 35 per cent. can be used, if, according to the new process of Buddeus, there is also 0.8 to 1 per cent. of copper also contained in the residue after burning. The process can be used on small quantities of material and intermittently. The cost of treating is said to be very low. There are many pulp mills in Europe using the process.

There has recently been advanced a proposal which would seem to make the pyrite process still more valuable. It is that out of the ores there may be extracted by simple washing sufficient copper and sulphur to make the operation very profitable, even when there is only 0.3 to 0.5 per cent. of copper. The iron residues are more useful when these two have been taken away and can be sold to advantage. The copper, which is extracted as a sulphate, can be obtained from the washing water by the addition of old iron, which causes the copper to be precipitated as a fine red powder which is usually about 90 to 92 per cent. pure.[2]

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[1] F. Deedmeyer, *Daily Cons. Tr. Rept.*, July 28, 1914.
[2] *Chem. Tr. Jour.*, and *Chem. Eng.*, Dec. 19, 1914.

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SULPHURIC ACID

The total production of sulphuric acid of all grades in the United States for the year 1914 was 3,762,417 short tons of 50° B. acid, valued at $24,163,331. Compared with the 1913 production of 3,538,980 short tons, this shows an increase of 223,437 short tons. This output does not include 21,993 short tons of fuming acid, valued at $316,596, but does include by-product acid—that is, acid obtained in the smelter industry. The acid produced at copper and zinc smelters in 1914 amounted to 950,798 short tons of 50° acid, valued at $5,190,293.

The most important commercial grades of acid are the 50° B. or chamber acid, containing 62.18 per cent. H_2SO_4 and having a specific gravity of 1.526; the 60° B. or tower acid, containing 77.67 per cent. H_2SO_4 and having a specific gravity of 1.706. This grade also includes concentrated chamber acid, or lead pan acid. The 66° B. or oil of vitriol, contains 93.19 per cent. H_2SO_4 and has a gravity of 1.835. Besides these are the 97 per cent. acid, monohydrate, and fuming acids, which contain from 5 to 20 per cent. of dissolved trioxide.

About five-eighths of all the acid produced is chamber acid, the most of which is used in the manufacture of fertilizers from phosphate rock, the manufacture of sulphate of ammonia in connection with the destructive distillation of coal, and the manufacture of alum. Most of the 60°

acid is used in the steel industry for pickling purposes; the 66° acid is principally employed in the purification of petroleum and in the manufacture of mixed acid in the explosives industry, as are also the higher strengths—the 97 per cent. and the fuming—the manufacture of reclaimed rubber and the general chemical industries.

The production of acid by grades is tabulated in detail below:

PRODUCTION OF SULPHURIC ACID IN THE UNITED STATES IN 1914, BY GRADES IN SHORT TONS

(Figures of the U. S. Geological Survey)

Grade.	Quantity.	Value.	Price per Ton.
50° Baumé	1,628,402	$9,712,056	$5.96
60° Baumé	551,955	3,376,242	6.12
66° Baumé	916,192	10,509,471	11.47
Other grades	65,890	882,158	13.39
Total	3,162,439	$24,479,927	7.74
Total reduced to 50° Baumé acid	(a)3,762,417	(a)24,163,331	$6.42

(a) Exclusive of 21,993 short tons of fuming acid, valued at $316,596.

PRODUCTION OF SULPHURIC ACID FROM COPPER AND ZINC SMELTERS IN 1912 1913 AND 1914, IN SHORT TONS

(Figures of the U. S. Geological Survey)

Source.	60° Baumé Acid.								
	1912.			1913.			1914.		
	Quantity.	Value.	Price per Ton.	Quantity.	Value.	Price per Ton.	Quantity.	Value.	Price per Ton.
Copper smelters	(b)321,156	(b) $1,985,704	(b)$6.18	336,019	$2,205,627	$6.56	348,727	$2,215,690	$6.35
Zinc smelters	(b)292,917	(b) 2,255,237	(b) 7.70	296,218	2,140,645	7.23	411,911	2,974,603	7.22
Total	(b)614,073	(b) $4,240,941	(b)$6.91	632,237	$4,345,272	$6.87	760,638	$5,190,293	$6.82
Total acid reduced to 50° Baumé.	(c)764,237	.....	.....	790,296	.....	.....	950,798	.....	.....

(a) The acid reported to the Survey includes that of strength of 50°, 53°, 60°, and 66° Baumé, and a small quantity of electrolyte and oleum. All strengths, with the exception of the electrolyte, have been reduced to both 50° and 60° Baumé, as given in the table.
(b) Inclusive of a small quantity of electrolyte.
(c) Exclusive of a small quantity of electrolyte.

The amount of by-product acid again shows considerable increase over the amount produced in 1913. The amount produced in 1914 is 950,798 tons, as against 790,296 tons in 1913, an increase of 160,502 tons, or a little over 20 per cent.

Markets.—The acid business was good during 1914, the year being characterized by a largely increased output, with slightly lower prices obtaining. Acid was quoted at $5.96 for 50° acid, $6.12 for 60° acid, and $11.47, for oil of vitriol, per ton.

Russia.—In the production of sulphuric acid which is made from both home-produced and imported sulphur there has been great progress.

The imported sulphur is mostly used in the Baltic provinces where many important chemical works exist. But in districts far from the coast, such as the Urals, sulphur is mined to a considerable extent and used for the production of acid. The chief development in this industry consists in the recovery of the sulphur from the hitherto waste fumes from the copper reduction factories and its conversion into sulphuric acid. Sulphur is found in the Caucasus also in fairly large quantities.[1]

Technology

Sulphuric Acid Towers.—If sulphuric acid towers are to be substituted for lead chambers, they should be designed and operated accordingly, but this is usually not the case. In the first place, there is not the same opportunity for the gases getting mixed. In a lead chamber of 1000 to 3000 cu. m. content the gases remain for ½ to 1 hr. in continuous motion and mixing, concentrated gases coming in contact with gases which have already become diluted, and so on. Through a tower of 100 to 300 cu. m. content the gases pass in a few minutes. While there is a perpetual dividing up and re-uniting of the gas currents, there is never an opportunity of fresh gases and of diluted gases coming together. Also, a lead chamber is able to rid itself quickly of any excess of heat by simple radiation. The tower has a much smaller radiation surface, moreover, the tower fillings act as a storage or reservoir of heat. Further, in a lead chamber the gases are repeatedly heated and cooled, which is impossible in a tower. These disadvantages of the tower can be overcome by the very simple remedy of providing behind the tower an "equalizer" ("Ausgleicher"), that is, a vessel in which the acid is removed from the gases, while the gases which are now more dilute and have been cooled may be returned by a special pipe line back to the entrance of the tower so as to pass through it again. There is obtained in this way a forced mixing of dilute and of fresh concentrated gases. Further, the reaction heat is gotten rid of in a simple way by air or by water-cooling. Temperature differences are produced, since the warm gases are cooled in the equalizer, and are heated again in their next passage through the tower. The output of the different towers and of the whole system may be regulated by this method within wide limits. The towers are better utilized and the expensive supply of acid running down over the filling may be largely reduced. Disturbances in operation and variations in output and temperatures may be equalized before they reach the towers.[2]

Opl System.—The system comprises six towers, through which the sulphurous gases are drawn by means of a suction fan, a coke filter at the

[1] *Chem. Tr. Jour.*, Jan. 30, 1915.
[2] *Chem. Ztg.*, July 30, 1914.

end of the series serving to retain sulphuric-acid mist. The first tower is sprayed with the nitrous-vitriol of the sixth tower, the second tower with that of the fifth, and the third with that of the fourth. Water is introduced into towers 2, 3 and 4 by means of atomizers operating in the roofs. For complete denitration, the acid overflowing from the towers 2 to 6 is is re-conducted over the first tower. The passage of the acid to and from the towers is effected by emulsifying the liquid with compressed air, the light froth which is produced rising to the required height and reacting rapidly, owing to the large surface of liquor exposed. The reaction space is only one-tenth of that required by the chamber system, and the time required for the production of tower acid is only 20 min., as against 4 to 6 hr. in the case of chamber acid. For making sulphuric acid of 60° B. (sp. gr. 1.71), the consumption of nitric acid of 36° B. (sp. gr. 1.332) is 0.88 per cent. of such acid.

The essentials of sulphuric-acid manufacture are: (1) the intimate mixture of the gases; (2) the dissipation of the heat of reaction without the adoption of special measures; and (3) the production of desired differences of temperature within the reaction space. These requirements are fulfilled in the chamber process, but are lacking in the ordinary tower process. By placing behind each tower an acid separator, capable of circulating the gases back to the tower, it is claimed that all the shortcomings of the tower system may be surmounted and advantages acquired as regards control and efficiency and also economy of nitric oxide.[1]

Acid-proof Lining for Ore Vats.—In treating low-grade copper ore, one of the methods frequently employed is to dump it into large concrete basins and apply a 10 or 12 per cent. solution of sulphuric acid. However, the difficulty encountered in this method is to get basins which will stand the effect of the acid. The usual procedure is to swab the interiors of the basins with an asphaltic mixture. The objection to this treatment is that the asphaltic coating is quickly destroyed by abrasion and has to be renewed at frequent intervals. Tests conducted recently in connection with the use of J-M acid-proof mastic, manufactured by the H. W. Johns-Manville Co., New York, for lining the acid basins, demonstrate that it is entirely successful in overcoming the difficulties heretofore encountered. Acid-proof mastic when laid 1½ in. thick, forms a tough, impervious coating which is unaffected by acid and successfully resists abrasion. The basis of this material is a pure natural asphalt which will give years of service in ore vats.

Concentration of Sulphuric Acid.—The concentration of sulphuric acid simply means the separation of the acid from water by the process of evaporation. The sulphuric acid as it issues from the chamber sys-

[1] *Chem. Ztg.*, **38**, 8–9.

tem is usually of a specific gravity of 1.560, containing 65.27 per cent. of sulphuric acid, and is evaporated until it attains a specific gravity of 1.840 or contains about 96 per cent. of sulphuric acid. The weak acid begins to lose water at about 122° F. and boils at 305° F. The strong acid boils at 563 °F.; but it is known that this sulphuric acid may be concentrated at a temperature much below its boiling point, namely, at a temperature of about 450° F.

The construction of apparatus for the concentration of sulphuric acid has, at times, had considerable attention. Many forms of apparatus have been invented, and many metals have been used in their construction from brittle glass to the expensive metals of gold and platinum. Of late years apparatus have been built of volcanic lava, but these, it will easily be seen, are very expensive, costing as much as £1500 ($7500). It is a fact that although some of these apparatus produced acid much cheaper, requiring less fuel and reducing the cost of labor, they very rarely produced it equal in color to that which was produced by the old-fashioned glass retorts, and for this reason the glass retorts are employed in some works to-day.

In the year 1890 Negrier introduced what is known as the capsule system of construction, which was further improved upon by Benker. It is an attempt to evaporate fractionally. This form of apparatus has had a very varied career. In the first plant porcelain capsules were used, and it may be that from the fragile nature of this material it was not persevered with. However, with the invention of a fused silica material for this purpose, this form of apparatus has again appeared, and plants of the capsule type have been erected in many places, again with varied results. Some firms, after several trials and experiments with furnaces of varied construction, have discarded them, preferring the type of apparatus in which the sulphuric acid is concentrated by contact with the furnace gases; but this type of apparatus does not produce an acid as clear as that which is made by the capsule or the glass retort systems.

Table I shows the specifications of the cost of a plant to produce 4 tons of sulphuric acid in 24 hr.

Table II shows the cost of producing 1 ton of acid by this plant.

Table III shows how the concentration of the acid proceeds.

The weak acid recovered by condensing the exit gases was of a specific gravity 1.240 and was equal to 2.23 per cent. of the weight of the acid produced. In the glass retort system the acid in the weak acid was usually equal to about 15 per cent. of the acid produced.

The great drawback in constructing this type of apparatus has been that of using a forced-draft furnace. Such a furnace gives too high a temperature in the lower part of the plant, which causes much bumping of the

capsules. In this way most of the capsules have been broken. An ordinary furnace with careful and regular working will produce economically a very colorless acid of satisfactory strength.[1]

TABLE I.—SPECIFICATIONS FOR PLANT FOR 4 TONS PER 24 HR.

	£	s.	d.
Fused silica basins, delivery pipes and coolers	43	8	.....
Acid-proof tiles, 1000 acid-proof bricks and cement for same	13	15	.....
10,000 ordinary bricks, including 500 arch bricks and concrete	27	10	.....
6000 fire bricks of various sizes	16	.....	.....
H wrought-iron girders and wrought-iron stays	14	12	.....
Cost of furnace and accessories	7	.....	.....
6 lead pans, lead vessels for silica coolers, lead vessels for worm type coolers, materials and labor.	44	10	.....
Iron plates for supporting lead pans	5	5	.....
Wood centers for arches, asbestos cord for seating capsules and sundries	3	10	.....
Materials and labor for condenser for exit gases, with connections	57	10	.....
Cost of labor for erecting plant	30	.....	.....
Total	265	.....	.....

TABLE II.—COST OF PRODUCTION OF 1 TON

	s.	d.
Fuel, coal, 2cwt. at 8s. 4d. per ton; fuel, coke breese, 1 cwt. 2 gr. at 4s. 6d. per ton	1	2½
Wages	2	.....
General expenses	3	2
	6	4½

TABLE III

	Per Cent.		Per Cent.		Per Cent.
Lead pan No. 1	.....	Capsule No. 4	78.84	Capsule No. 13	87.16
Lead pan No. 2	.....	Capsule No. 5	79.90	Capsule No. 14	88.21
Lead pan No. 3	65.25	Capsule No. 6	80.83	Capsule No. 15	89.12
Lead pan No. 4	65.25	Capsule No. 7	81.47	Capsule No. 16	91.08
Lead pan No. 5	72.0	Capsule No. 8	82.5	Capsule No. 17	92.0
Lead pan No. 6	74.0	Capsule No. 9	83.36	Capsule No. 18	93.08
Capsule No. 1	75.25	Capsule No. 10	84.42	Capsule No. 19	94.37
Capsule No. 2	76.0	Capsule No. 11	85.34	Capsule No. 20	95.25
Capsule No. 3	77.66	Capsule No. 12	86.23		

Advances in Manufacture.—Advance has been made in the prevention of the escape of metallic fume and in the reduction of acid escaping with chimney gases, but the acidity of gases from lead- and copper-smelting works presents a problem which still awaits solution, and the amount of sulphur escaping into the air from the blende calciners in the immediate neighborhood of Swansea (within an area of 4 sq. miles) is equivalent to approximately 80 tons sulphuric acid of 150° Tw. (sp. gr. 1.75) per 24 hr. At one large spelter works chambers are being erected for the manufacture of sulphuric acid from the gases, and it is suggested that by calcination in muffle-type furnaces at a central works, or by arrangement

[1] W. Mason, *Met. Chem. Eng.* Jan. 1, 1915.

with vitriol makers, the whole of these waste gases might become a source of profit instead of polluting the air.

More attention is now given to providing wider space between sulphuric-acid chambers, thus affording greater cooling space and condensing power, longer life to the chambers, greater ease in effecting repairs, and opportunity for keeping the outside of the chambers clean; the practice of limewashing chambers and woodwork is commended as tending to preserve the latter and as making evident the slightest leak. Incasing flues from burners to denitrating columns in cast iron has been found successful in preventing local escapes due to weakening of the brickwork by heat.

Appreciative reference is made to an apparatus called "Nitrophor," devised to control automatically the supply of niter to the system by responding to alterations of temperature of the chamber gases, but it is pointed out that influence may be exerted by factors other than the chemical actions taking place in the chambers.

Glass-packed absorbing towers are being used in increasing numbers, and water sprays in lieu of steam for supplying moisture to the chambers are on the increase, although in Scotland there is said to be some tendency to return to the older system. The injection of sodium-nitrate solution into the first chamber instead of "potting" nitrate in the burner flue is also becoming popular. In Scotland, fans for controlling draft and additional Gay-Lussac towers are in more general use, and a strong solution of soda ash has been employed at several works to reduce obstruction of towers by chemical deposits, with good effect. The undue escapes previously reported during the concentration of acid in over-heat pans were greatly lessened. Kessler plant came into more extended use during the year; the substitution of mechanical means for obtaining the necessary draft further replaced the high-pressure steam-jet aspirator originally used in all installations of this form, with advantage as regards steam consumption and strength of recovered weak acids. The cascade system was also further adopted, silica ware, "tantiron," and, to a small extent, "ironac" being in use for making the evaporating vessels.[1]

Profits in Sulphuric Acid.[2]—It is generally understood that the Tennessee Copper Co. has long been a producer of sulphuric acid as a by-product, but within the last year or so the production of sulphuric acid has become the leading business of the company, and a business that, having already become immensely profitable, is growing still more profitable with each succeeding year if not, indeed, with each succeeding month, until to-day the profits derived by the company from the production of

[1] *Eng. Min. Jour.*, **99**, 1910.
[2] *Salt Lake Min. Rev.*, Feb. 15, 1915.

sulphuric acid alone are sufficient to pay the entire dividends on the $5,000,000 of stock that the company has outstanding, and leave a considerable surplus over. This result is to-day being accomplished without taking into consideration the copper production of the company at all.

Within the last few months the output of sulphuric acid has increased from around 600 tons a day to a maximum record of 820 tons in a day, with an average production at the present time of at least 700 tons a day. The sulphuric acid plant of the Tennessee Copper Co., which is by all odds the largest in the world, runs day and night every day in the year, except for a few days annually when it has to be closed down to put in new blower fans. Figuring the running time per year at 350 days, and the daily output at 700 tons in order to be conservative, we have an annual output of 245,000 tons of acid.

The capitalization of the company is 200,000 shares, of a par value of $25 a share. On these shares annual dividends are paid at the rate of $3 a share, so that the annual dividend payments at the present rate call for disbursements to stockholders of $600,000 a year. The acid business provides all of this money, even on a most conservative basis of figuring, and leaves an annual surplus of $100,000. This surplus, of course, is still further increased by the copper production, which in normal time runs from 15,000,000 to 20,000,000 lb. annually, and on which there is a profit, with copper at the normal price of 14 to 15 cts. a pound, of $600,000 to $700,000. A production of 15,000,000 lb. sold at 14 cts. a pound will yield a profit of $500,000 which, added to present profits from the acid production amounting to $700,000, makes a total of annual profits amounting to about $1,200,000, or twice the annual dividend requirements at the present rate of payment to the stockholders.

Having shown how immensely profitable and important the sulphuric acid business is at present, the next question to be considered is the amount of ore in the property from which the products can be made. On that point authorities say that the ore easily in sight is sufficient to last from 40 to 50 years. But it should be borne in mind that the ores of the Tennessee Copper Co. have not been fully exploited. At no point have they been worked out. At no point has the bottom of the ore-bodies been found. The ores of the Tennessee Copper Co. are the only ores in the world in large body, with the exception of those of the Rio Tinto mine in Spain, from which sulphuric acid is made.

The formation of the ore-body is the same as that of the Rio Tinto mine. The Rio Tinto mine in Spain has been worked for some 3000 years, and to-day the pyrite from that mine is shipped to the United States and all over the world and goes into the manufacture of sulphuric acid. Therefore, a supply on hand to last for half a century, with large

unexplored deposits, and with the record of the Rio Tinto mine, nobody now living need concern themselves seriously with the probable duration of the ores in the Tennessee Copper Co.'s property.

The pressure for sulphuric acid from manufacturers is so great that the Tennessee Copper Co. has plans in hand and practically completed for expanding the mining and hoisting operations fully one-third, which will increase the copper output to 18,000,000 or 20,000,000 lb. annually, and necessarily increase the acid output also. This can be done by electrifying the hoisting apparatus, which can be accomplished at a small cost. The work of expanding these facilities will probably be completed during 1915. It is pretty safe to predict that it will not be very long before the acid output of the Tennessee Copper Co. can reach an average of 1000 tons a day. The cost of production, under such an output, will be reduced materially.

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TALC AND SOAPSTONE

By Frederick B. Peck

In the preceding volume of this publication the chemical composition, mode of occurrence, origin, and uses of talc and soapstone were somewhat fully treated. It will therefore be unnecessary to consider these phases of the talc and soapstone industry, and we may proceed to a brief statement of the conditions of trade in the industry during the past year, note new developments, and call attention to possible fields of expansion.

So far as can be determined, there has been little change in the activities of the talc and soapstone industries within the boundaries of the United States during the year. Let us consider briefly by states some of the prominent facts regarding the production of these materials.

New York, the chief producer of talc, is far in the lead, having contributed for many years more than one-half of the total production of the United States. In 1913 its production was 55 per cent. of the total for this country, and in 1914, about 79 per cent.

Virginia, the chief producer of soapstone, is responsible for more of this material than all the other states of the Union combined. Add to this fact the further knowledge that the United States produces more soapstone than all the other countries of the world combined, and the prominence of Virginia as a soapstone producer is evident. In the rough, as quarried, soapstone is worth $2 a ton; sawn into slabs its value exceeds $15 a ton, and when manufactured into laundry tubs its value is about $30 a ton. Virginia furnishes about 95 per cent. of the supply of the country.

One of the growing uses for talc is as a foundry facing. Heretofore graphite has been largely used, but there has recently been a very remarkable increase in the price of graphite and foundrymen for this reason have been looking for a satisfactory substitute. For this reason we may look for a more and more general use of talc as a substitute for graphite by foundrymen. The so-called "Bull Run Talc" of Fairfax County, Virginia, when properly ground and bolted, has proved to be a cheap and excellent substitute for graphite.

The talc is ground between rather slowly revolving 4-ft. French buhrstones and bolted through silk bolting cloth. This talc has been used

in the manufacture of foundry facing since 1907. It is reported as analyzing:

SiO_2	54.40
MgO	27.01
Fe_2O_3	9.54
Al_2O_3	5.86
CaO	0.60
H_2O	3.60
	101.01

Pennsylvania and New Jersey have long been steady producers of talc and soapstone. Here the local combination of minerals leads us to a consideration of a third closely allied mineral, serpentine, which by alteration may produce talc.

The entire production of Pennsylvania and New Jersey comes from quarries on either side of the Delaware River, in Pennsylvania and New Jersey, a mile or so northeast and southwest of the city of Easton. The rock is in part talc and in part serpentine, and two kinds of material are produced:

1. Ground rock, which sells as "mineral pulp" and is used largely in the manufacture of paper and paint.

2. Blocks, consisting chiefly of serpentine, which are sawn and polished for decorative purposes. Nearly all of the quarries of the region have at some time either produced, or are now producing, both kinds of material. A few years ago a company was formed which purchased, and for a time operated, one of the two largest quarries of the region. This quarry had for years been producing blocks of light green serpentine, having in it an irregular sprinkling of pink dolomite crystals. This rock, on being sawn into slabs and polished, presented a pleasing contrast in colors and the prepared material was sold under the trade name of "Verdolite," a contraction of the words "Verd-Antique" and "Dolomite." The company then owning and operating the quarry was known as the Verdolite Co.

This combination of minerals did not prove to be very persistent, the pink dolomite being only sporadically present, so that large quantities of the rock could not be relied upon. Later the property was purchased by C. K. Williams and Co., paint manufacturers, and the Verdolite Co. went out of existence and with it vanished the trade name "Verdolite." The new company is operating the quarry chiefly for rock which it grinds, a part of which is sold to the paper and rubber manufacturers located south of Easton on the Delaware River. Much of the product is consumed in the manufacture of mineral paint.

A comparison of chemical analyses of the Easton rock from both sides of the Delaware River, in Pennsylvania and New Jersey, with theoretical analyses of pure talc and serpentine shows it to consist largely of serpentine, though talc is also present.

CHEMICAL ANALYSES

	SiO_2.	MgO.	CaO, Al_2O_3, Fe_2O_3.	H_2O.	
Theoretical talc	63.5	31.7	.....	4.8	100.0
Theoretical serpentine	41.1	43.0	.....	12.9	100.0
Easton rock, Penna. side	42.98	40.79	2.30	13.73	99.80
Easton rock, Penna. side	46.80	38.70	3.96	10.64	100.10
Easton rock, New Jersey side	45.23	38.34	4.09	12.30	99.96

These analyses of the local Easton rock were made in the chemical laboratory of Lafayette College and the samples analyzed were average samples of the bulk of the rock used for grinding purposes.

While the scope of this paper must be confined chiefly to a consideration of talc and soapstone, we may perhaps be allowed to make brief mention of the preparation of polished serpentine at Easton. As previously stated, serpentine is more abundant here than talc. Within the past 10 years a separate industry has arisen. The stone-sawing and polishing concern of H. A. Schweyer and Co. is producing considerable amounts of polished serpentine of superior grade for interior decoration. The finished product is sold under the trade name of "Sylvan Green." The prepared stone sells at $1.25 to $2 per sq. ft.

This enterprise has been steadily growing for the past 10 years and is now doing a thriving business. It contemplates the development of other properties in the southern part of the state.

The recent discovery of talc of excellent quality and in commercial quantities in San Bernardino and Inyo Counties, California, promises much for the industry in the western part of the United States, and the demand for talc in the West may be supplied from this locality, thus saving the expense of a transcontinental haul.

The importance of this discovery to the industry, the quality, quantity and mode of occurrence have been fully described by J. S. Diller in *Mineral Resources of the U. S.*, 1913 (page 157, *et seq.*).

These deposits occur along the border of a diorite intrusion into banded, impure limestones. The effect of the diorite intrusion on the limestones seems to have been to alter them to masses of tremolite, which were subsequently altered by dynamical and other processes to talc. The deposits have a northwest-southeast strike.

The talc masses range in thickness from 0 to 12 ft., varying somewhat abruptly, and they thin out both vertically and horizontally to mere films.

The quality of the talc is excellent, being exceptionally white, soft, and slippery, and under the microscope it shows a finely fibrous character, as does most of the talc elsewhere that results from the alteration of the mineral tremolite.

These deposits have been opened and to a certain extent developed in three localities: Zabriskie and Tecopa in Inyo County, and at Riggs, San Barnardino County. The deposit at the last-named station (Riggs) which is located on the Tonopah and Tidewater Railroad, 10 miles north of Silver Lake, has been traced northwest and southeast for nearly a mile and opened at several points. All of these deposits occur within a stretch of country 40 miles long in a northwest and southeast direction, and 20 miles wide in an east-west direction.

Talc and soapstone are abundant in the eastern provinces of the Dominion of Canada, where they result from the alteration of dolomitic limestones, serpentine and basic igneous rocks. *Mining Journal*, Jan. 16, 1915, prints the following:

"Near Madoc, in the County of Hastings, Ontario, an extensive body of white, massive talc has been mined for some years, part of the product being shipped in lump form to the United States and the balance milled locally. The mineral is of high quality, low in lime and free silica, and commercially is considered quite equal to the fine French varieties. It has been formed by the metamorphism of a magnesia limestone, due to the proximity of an intrusion of granite. A slightly discernible foliation is noticeable in the mineral and some tremolite may be seen scattered through the body, suggesting an intermediate tremolitic stage during the alteration from dolomite. North of this occurrence some 10 miles another body of similar material is being mined and milled on the ground, turning out an excellent product. Through the surrounding district other occurrences of white and colored talcs may be noticed, many of which are capable of supplying material suitable for a variety of uses."

The following is an analysis of the Hastings Co. talc:

SiO_2	60.45
MgO	29.84
Al_2O_3	0.27
FeO, Fe_2O_3	2.82
NiO	0.50
CaO	0.50
H_2O	6.74
	100.89

Serpentine, talc, and soapstone are plentifully distributed through the eastern part of Quebec, and the talc deposits in particular have been highly spoken of, though up to the present they have been entirely ignored.

Figures showing the amounts of talc and soapstone produced by the different states are as yet not available, but the tables as compiled for the last volume of this publication, showing the production not only by states, but also by countries, for the year 1913, are given below.

One other use for which talc gives great promise is as a lubricant. In an extremely finely divided or "deflocculated" state talc remains sus-

pended in water or oil. Deflocculated graphite is used in the manufacture of heavy lubricants, and deflocculated talc appears to be equally serviceable. This process of deflocculation, as devised by a German chemist, F. Thalberg, is accomplished by one of the two following methods.

Clean powdered talc is heated with ammonium carbonate and the heated mass plunged into cold water. A fairly stable suspension is obtained. If a dry stream of ammonia is passed over pulverized talc the result is even better and an excellent, difficultly filtrable suspension in water or in oils is produced. The drying of the ammonia-treated talc must be done in vacuum, since heat causes agglomeration of the particles. After suspension of the treated talc in a liquid medium, heating has no effect. The equilibrium is probably $(4SiO_2.3MgO)H_2O + NH_3 \rightleftarrows (4SiO_2 3MgO)NH_3 + H_2O$.

The 1914 production of talc, according to the U. S. Geological Survey was 151,088 tons, and of soapstone, 21,208 tons, a total of 172,296 tons, valued at $1,865,087, nine states contributing to the production.

PRODUCTION OF TALC AND SOAPSTONE BY COUNTRIES
(In tons of 2000 lb.)

	U. S. (a)	France. (b)	Italy. (c)	Canada. (c)	Spain. (d)	Austria. (c)	Ger. Empire, Bavaria. (d)
1906	120,644	29,061	9,624	1,234	3,978	.....	2,131
1907	139,810	38,262	13,574	1,534	15,294	.....	2,203
1908	117,354	37,053	12,048	1,016	5,214	.....	2,424
1909	130,338	38,433	13,228	4,350	6,154	.....	2,567
1910	150,716	42,316	13,727	7,112	5,143	.....	3,398
1911	143,551	44,092	15,600	7,300	6,226	15,212	3,782
1912	159,270	(e)	15,800	8,270	(e)	(e)	3,551
1913	175,833	(e)	23,530	12,250	(e)	(e)	(e)
1914	.....	.....	.....	10,808	.....	.....	.....

(a) Talc and soapstone. (b) Talc, soapstone and asbestos. (c) Talc. (d) Soapstone. (e) Statistics not available.

PRODUCTION OF TALC AND SOAPSTONE BY STATES

	1910.		1911.		1912.		1913.		1914.	
	Tons.	Value.	Tons.	Value.	Tons.	Value.	Tons.	Value.	Tons.	Value.
New York	71,710	$728,180	62,030	$613,286	66,867	$656,270	81,705	$788,500	.....	.....
Vermont	25,975	136,674	29,488	200,015	42,413	275,679	45,547	327,375	.....	.....
New Jersey and Pennsylvania	13,192	62,833	12,131	54,319	10,400	50,519	11,308	80,780	.....	.....
Virginia	25,908	519,781	26,759	660,926	25,313	576,473	26,487	615,558	.....	.....
Massachusetts	7,475	52,204	7,642	36,883	.....	.....	.....	.....	.....	.....
North Carolina	3,887	69,805	3,548	57,101	3,542	63,304	4,676	48,817	.....	.....
California	.....	.....	.....	.....	1,169	15,653	952	6,000	.....	.....
Other States	.....	.....	.....	.....	9,566	69,065	5,158	41,067	.....	.....
Total	.....	.....	.....	.....	159,270	1,706,963	175,833	1,908,097	172,296	1,865,087

Talc only ..... California and New York.
Talc and soapstone ..... North Carolina, Vermont and Virginia.
Soapstone only ..... Rhode Island.
Talc and serpentine ..... New Jersey and Pennsylvania.
Pyrophyllite ..... North Carolina.

TIN

Attempts at Domestic Tin Production[1]

Much attention has been directed of late to the apparently anomalous fact that although the United States consumes about 40 per cent. of the tin produced in the world, all of it is imported into this country, no foreign ore being smelted here, nor is there any appreciable production from domestic ore, most of that produced being sent abroad for smelting. It is interesting in this connection to review the attempts which have been made to develop a domestic production. There seems to be a general impression that there are no tin deposits of any value in this country; as a matter of fact there are several of distinct promise, but circumstances have been unfavorable to their development.

Perhaps the most promising of our deposits are those which lie along the border line of North and South Carolina, extending from Cherokee County, in the latter state, over into Lincoln County, North Carolina. Thirty years or more ago these were brought to the attention of Phelps, Dodge & Co., which firm took an option on a large area in which cassiterite occurs as an original constituent of pegmatite dikes. A careful study of the deposits indicated that if worked on a sufficiently large scale the ore could be mined at a profit and would yield about 15 lb. of tin per ton of ore. The price of tin fluctuates widely and there was room for doubt whether it might not decrease to below 20 cts., the price at that time, at which the indicated operating profit would disappear, so the option was surrendered. Since then the area has been divided into small holdings, some of which have been worked in a rather desultory manner, and the Cherokee Tin Mining Co., at Gaffney, in South Carolina, and the Piedmont Tin Mining Co., at Lincolnton, North Carolina, are still engaged in developing their holdings. If it were feasible to organize a great operating company, like the Utah Copper, it seems quite probable that a notable production might be developed in this area. The climate is favorable, labor and fuel cheap. Even if concentrates only were produced at first, they could be marketed abroad, temporarily, as freight rates to Norfolk are cheap, and cotton ships take heavy material for ballast at low rates.

About the same time numerous veins, resembling in many ways the

[1] Abstracted from editorials *Min. Sci. Press*, Sept. 26 and Nov. 21, 1914.

famous deposits of Cornwall, were discovered in the Shenandoah Valley of Virginia. They yielded 20 lb. of tin per ton in mill tests, and it would have been easy to finance the development of the mine, but a valid title to the property could not be secured.

About the same time a group of British investors took up the Harney Peak Tin Mining Co., a corporation previously formed to work a group of claims near Harney Peak in the southern Black Hills of South Dakota. The tin-bearing veins proved to be of very low grade, as much of the black mineral which many regarded as cassiterite in the hand specimen proved to be tourmaline. It was not long before the venture disclosed itself as a fiasco, and the notoriety which the venture attained has undoubtedly reacted to discourage the investing of capital in tin mines in this country. Not far from this property are the mines near Tinton, South Dakota. These are of much more promise, but the first attempt to work them ended in failure, not due, however, to the character of the ore. Since that time the property has been considered by more than one group of investors, but so far not much progress has been made toward the reopening of the mines.

Of recent years a small amount of tin concentrate has been produced in Alaska, chiefly by dredging in an area a short distance east of Cape Prince of Wales. While these are of local importance, they have as yet produced only a fraction of 1 per cent. of our domestic tin requirements. Some years ago the Standard Oil Co., one of the largest users of tin cans, thought to provide itself with an independent supply of tin and thereby obtain better rates from the plate manufacturers. As tin concentrate from the Malay States could be carried to New York at a low rate by the Standard Oil steamers, which ordinarily returned empty from those waters, a tin-smelting plant was built near the refinery at Bayonne, on New York Bay, at a cost of about $300,000, and work was started. The local smelters in the Malay States were naturally disturbed by this interference with their business and made representations to the local government, with such success that a prohibitive duty on exports was laid and the venture ended in failure.

The situation has materially changed since the unfortunate venture of the Standard Oil Co. At that time the tin output of Bolivia was small; now it is about two-thirds of our yearly imports. The concentrate is now being shipped to Hamburg or Liverpool *via* Magellan, a distance of about 10,000 miles, for smelting. Now that the Panama Canal is open, shipments can make the short cut, reducing the distance to 7000 miles. The distance to New York is, however, only 4000 miles, and as smelting costs here should closely approximate those in Europe, it may be feasible to transfer the industry to the vicinity of New York or Baltimore.

IMPORTS OF TIN INTO THE UNITED STATES

Year.	Pounds.	Value.	Year.	Pounds.	Value.	Year.	Pounds.	Value.
1903..	83,133,847	$22,265,367	1907.	82,548,838	$32,075,091	1911.	106,936,872	$43,390,639
1904..	83,168,657	22,356,896	1908.	82,503,190	23,932,560	1912.	116,003,385	50,371,102
1905..	89,227,698	26,316,023	1909.	95,350,020	27,559,937	1913.	104,282,230	46,900,314
1906..	101,027,188	37,446,508	1910.	105,137,740	33,921,449	1914.	95,049,612	32,861,188

According to the United States Geological Survey, an equivalent of only 84 short tons of tin ore, carrying 60 per cent. metallic tin, valued at $36,970, was produced in the United States during 1913. The largest quantity of tin was taken out on Buck Creek, Alaska. The total production of Alaskan tin mines since the industry started in 1902, is about 550 tons of metallic tin, valued at $432,000. In 1914 one dredge was operated on the Buck Creek placer-tin deposits throughout the open season. Two others were operated for a part of the season on Anikovik River, working on deposits carrying both gold and tin. Operations were also continued and some tin was produced at the Lost River lode-tin mine. All these localities are in Seward peninsula. Tin was also produced from several deep placer mines in the Hot Springs district, operated chiefly for the recovery of gold. It is estimated that nearly 50 tons of stream tin was recovered from these placers in 1914. This output could be considerably increased, for only a few of the miners make a systematic attempt to recover the tin.

The Tin Market[1]

At the beginning of 1913 the price of tin in New York was about 50 cts. per lb., and it had begun to look as if even a higher price might be realized, owing to shortage in the supplies, but contraction in consumption more than offset any shortage, and the general tendency throughout 1913 was declining, the price at the end of that year being about 37½ cts.

In 1914 the general tendency of tin was also declining, although in January and February there was a small rally in common with what was experienced by the other metals. However, by the mid-year tin was down to about 30 cts. per lb. The outbreak of the war caused a tremendous scare about tin supplies, all of which come by sea and were thought likely to be cut off entirely. The price rose to fancy prices for the small quantity of tin actually in stock in New York, 75 cts. per lb., even, being realized. This represented, however, what was merely picayune business—1-ton to 5-ton lots—and was in nowise representative of a broad commodity price.

During August there was no wholesale market, for the simple reason that there was no wholesale supply. By the end of that month

[1] *Eng. Min. Jour.*, Jan. 9, 1915.

supplies began to come in, and the fancy prices immediately disappeared. In September tin was down to the basis of about 32½ cts. per lb., and in October it was about 30¼ cts. In November and December it was a few points higher. The position of tin seems to be that the high prices of 2 years ago stimulated production, while consumption has diminished along with the general contraction of business experienced in the United States in 1913 and 1914.

AVERAGE MONTHLY PRICES OF TIN PER POUND IN NEW YORK (*a*)

Year.	Jan.	Feb.	Mar.	Apr.	May.	June.	July.	Aug.	Sept.	Oct.	Nov.	Dec.	Year.
	Cts.	Cts.	Cts.	Cts.	Cts.	Cts.	Cts.	Cts.	Cts.	Cts.	Cts.	Cts.	Cts.
1900	27.07	30.58	32.90	30.90	29.37	30.50	33.10	31.28	29.42	28.54	28.25	26.94	29.90
1901	26.51	26.68	26.03	25.93	27.12	28.60	27.85	26.78	25.31	26.62	26.67	24.36	26.74
1902	23.54	24.07	26.32	27.77	29.85	29.36	28.38	28.23	26.60	26.07	25.68	25.68	26.79
1903	28.23	29.43	30.15	29.81	29.51	28.34	27.68	28.29	26.77	25.92	25.42	27.41	28.09
1904	28.85	28.09	28.32	28.13	27.72	26.32	26.57	27.01	27.78	28.60	29.18	29.292	27.99
1905	29.325	29.262	29.523	30.525	30.049	30.329	31.760	32.866	32.095	32.481	33.443	35.835	31.358
1906	36.390	36.403	36.662	38.900	43.313	39.260	37.275	40.606	40.516	42.852	42.906	42.750	39.819
1907	41.548	42.102	41.313	40.938	43.149	42.120	41.091	37.667	36.689	32.620	30.833	27.925	38.166
1908	27.380	28.978	30.577	31.702	30.015	28.024	29.207	29.942	28.815	29.444	30.348	29.144	29.465
1909	28.060	28.290	28.727	29.445	29.225	29.322	29.125	29.966	30.293	30.475	30.859	32.913	29.725
1910	32.700	32.920	32.403	32.976	33.125	32.769	32.695	33.972	34.982	36.190	36.547	38.199	34.129
1911	41.225	41.614	40.157	42.185	43.115	44.606	42.400	43.319	39.755	41.185	43.125	44.655	42.281
1912	42.529	42.962	42.577	43.923	46.053	45.815	44.519	45.857	49.135	50.077	49.891	49.815	46.096
1913	50.298	48.766	46.832	49.115	49.038	44.820	40.260	41.582	42.410	40.462	39.810	37.635	44.252
1914	37.779	39.830	38.038	36.154	33.360	30.577	31.707	(*b*)	32.675	30.284	33.304	33.601	

(*a*) As reported by *Eng. Min. Jour.* (*b*) No quotations.

AVERAGE MONTHLY PRICE OF TIN IN LONDON (*a*)
(In pounds sterling per ton of 2240 lb.)

Year.	Jan.	Feb.	Mar.	Apr.	May.	June.
	£ s d	£ s d	£ s d	£ s d	£ s d	£ s d
1902	105. 6 .5	114 .4 .9	115.10 .6	125.14 .2	134.13.10	129.12.10
1903	127.12 .6	133 .8 .1	137 .0 .6	136.19 .2	133.12 .0	127.11 .0
1904	130.10 .4	125.13 .6	126 .9 .8	127 .5 .1	125 .7 .2	119.11 .1
1905	131 .5.11	131 .3 .6	134.17 .2	140.11 .8	136.11 .8	138 .3 .6
1906	164.11.10	166 .0.10	166 .1 .2	176.14 .5	192 .6 .4	178 .0 .7
1907	190 .4 .0	191.18 .9	188.17 .6	187 .1 .2	191 .1.10	187.10.11
1908	128 .9 .0	128.14 .1	137.19 .8	143.12.10	135.11 .6	127.12 .2
1909	127 .7 .3	127.15 .3	130 .6 .7	133 .8 .3	131.16.10	133 .4 .8
1910	148 .3 .6	149.13 .0	147 .4.11	149.19 .3	150 .1 .8	148.13 .1
1911	187.17.11	189.12.10	182.12 .4	193 .0.10	197.15 .4	207 .7 .9
1912	191.14 .0	195 .4.10	192.15 .0	200 .8 .3	209 .6 .1	205.18 .8
1913	238 .5 .6	220 .2.10	213.12 .4	224 .3 .2	224.2 .10	207 .4 .2
1914(*b*)	171.18 .1	181.11 .1	173.12 .4	163.19 .3	150.14 .4	138 .6 .5

Year.	July.	Aug.	Sept.	Oct.	Nov.	Dec.	Year.
	£ s d	£ s d	£ s d	£ s d	£ s d	£ s d	£ s d
1902	127 .3 .2	126.10 .0	121.10 .7	117.11 .3	115 .2 .3	115.13 .5	120.14 .5
1903	125 .1 .7	127.16.10	120 .9 .6	115.17 .1	116.13 .9	125.15 .0	127 .6 .5
1904	119.18 .6	122 .5 .9	126 .7 .7	130.11 .6	133 .0 .5	133.15 .6	126.14 .8
1905	144 .6 .8	150 .5 .6	146.11 .9	148 .3 .6	152 .5 .3	162.14 .3	143 .1 .8
1906	170.12 .5	180.19.11	184.15 .3	195.15.11	195.15.10	195.19 .9	180.12.11
1907	188 .0 .2	170 .5 .9	166 .6 .6	146 .7 .7	138 .8 .8	125.10 .4	172.12 .9
1908	131 .6.10	134.16 .2	131 .6 .8	133 .8 .8	137 .8 .3	132 .4 .7	133 .2 .8
1909	131.19 .1	135.18 .3	137.14 .6	138.13 .2	140 .0 .3	149 .2 .3	134.15 .8
1910	149 .2 .1	155 .8 .2	160 .8 .7	164 .4 .9	166.18 .0	173.17 .3	155 .6 .3
1911	193 .2 .0	190 .9 .7	180.16.11	187 .2 .9	194.19 .4	203 .7 .2	192 .7 .3
1912	202 .8 .3	208 .3 .0	223.19 .6	228 .9 .1	227.16.10	226.17 .8	209 .8 .5
1913	183.10 .3	188.14 .7	193 .1 .6	184.16 .9	180.17 .5	171.15 .9	206 .5 .7
1914(*b*)	142.10 .4	(*c*)	(*c*)	(*c*)	139. 7.10	147. 2 .4	

(*a*) As reported by Metallgesellschaft, Frankfurt-am-Main. (*b*) As reported in *Eng. Min. Jour.*
(*c*) No quotations.

London.[1]—Though tin, unlike copper, did not fall so low as it has done in the previous 10 years, there was at times no market, and consequently it is almost meaningless to say that £118 or thereabouts was the lowest figure touched. Generally speaking, the price was a declining one from February onward, until the bottom fell entirely out of the market on the outbreak of the war. From the re-opening of the Metal Exchange on October 29 there was a steady improvement, and the year closed at £146 10s. as compared with £168 5s. for the beginning of the year. The depression in tin mining began to be felt toward the end of 1913, and consequently when the war broke out production was already on a somewhat reduced scale. Tin mining is a very scattered industry, and it is supported by no large financial interests such as play an active part in copper, spelter, and lead. With the sudden disappearance of markets a general closing down was so obviously imminent that various interests intervened in different parts of the world to mitigate the loss which threatened tin miners generally if the mines had to close down. The effect of these measures has undoubtedly been to enhance production greatly above what it would have been had economic forces been allowed to operate without interference. At the same time, it must be recognized that production generally must have been at a loss, and many producers must envy the strong position of the Dutch government, which can apparently afford to bide its time until the level of prices is reached at which its tin can be sold at what, when all costs are included, is a remunerative figure.

World's Production and Consumption

The normal yearly output of tin throughout the world is in round figures 125,000 tons, as compared with 100,000 tons 10 years ago. The increase is distributed among all the producing countries with the exception of Australia. The greatest increase is shown by Bolivia, a country that promises still further expansion. The output of the Malay peninsula, commonly called "Straits" tin, is about 63,000 tons per year, of Bolivia 20,000 tons, the Dutch East Indies 17,000 tons, Cornwall 5000 tons, Australia 5000 tons, South Africa 2600 tons, and Nigeria 4500 tons. The only figures available for China are those of export, which averages 6000 tons, but large quantities must also be used locally. Smaller amounts are produced in Germany, France, northwestern Spain, Portugal, Mexico, and Alaska. As regards the future, Nigeria is the only region besides Bolivia that promises an increase of output. It is too early to have accurate figures for the output for 1914, but judging by the periodical reports issued during the year, the total production will be about 120,000 tons.

[1] *Min. Jour.*, Jan. 23, 1915.

PRODUCTION OF TIN METAL IN THE WORLD
(In metric tons)

Country in Which Smelted.	1909.	1910.	1911.	1912.	1913.	1914.
Australia(*m*)	6,450	5,500	5,150	5,130	4,870	(*e*)1,550
Austria-Hungary(*a*)	52	39	16	14	13	.....
Banka, sales in Holland(*m*)	12,150	13,631	15,147	16,111	15,173	.....
Billiton, sales in Holland and Java(*m*)	2,280	2,240	2,240	2,243	2,243	.....
Bolivia, metal exported to England(*w*)	834	1,003	464	552	(*e*)300	.....
China, exports(*a*)	4,516	6,510	6,056	8,785	3,889	(*e*)2,000
France(*m*)	*Nil.*	*Nil.*	500	500	1,200	.....
Germany, mainly from Bolivian ores(*a*)	8,995	11,394	12,426	10,646	(*m*)11,500	.....
Japan(*a*)	23	23	155	36	(*e*)50	.....
Straits Settlements, exports(*m*)	61,540	57,490	57,944	61,528	65,640	66,327
United Kingdom, from domestic ores(*a*)	5,282	4,874	4,950	(*m*)5,338	(*m*)5,300	(*e*)5,000
United Kingdom, from imported ores(*m*)	11,890	13,055	13,850	13,600	16,700	.....
Total production of metal	114,012	115,759	118,898	124,483	126,878	.....

(*a*) Official statistics. (*e*) Estimated. (*m*) *Metallgesellschaft.* (*w*) Watson & Co.

NOTE.—Among the more important omissions from the above table, due to imperfect statistics are the following: (1) Output of native smelters in Central and South Africa; (2) Exports from Siam and the Dutch East Indies to India, China, Korea and Japan; (3) Local consumption in Straits Settlements, Siam and Dutch East Indies.

As regards consumption, it is difficult to speak. It stands to reason that it has been seriously affected, but all considerations suggest the conclusion less so than production. The English tinplate output was less last year, exports being 59,000 tons lower. On the other hand, the American production is estimated at 75,000 tons more than in 1913. Consequently, it is necessary to consider only possible declines in German, Italian, and other Continental makes of tinplate, which are not likely in the gross to amount to very much. Probably there was little or no decline in the consumption of tinplate last year. The other commercial uses of tin were, of course, affected by the check on the activity of trade all over the world caused by the approach of the war and by the shock to which its outbreak gave. Against that, however, is to be set the enhanced demand due to special requirements of the war, and if one can judge by the activity of tin exports, these requirements are very extensive. The total deliveries in tin in America last year are given as 41,700 tons, compared with 43,900 tons in 1913—a decline, that is, of 2200 tons. As America is generally assumed to be responsible for about two-fifths of the world's requirements, we might calculate on this basis that the world's consumption declined last year by something like 5500 tons, as compared with a decrease in production, which, allowing for the increase in Banka stocks, stands on the foregoing figures at about 12,000 tons. Such a figure, representing a decline in stocks of over 6000 tons, can not be ignored, and is in itself an assurance of better times to come. What is impossible to judge is how far the declines, especially in the case of Bolivia and Banka, are due to temporary and accidental rather than to more enduring causes, and are already giving place to resumption of supplies in normal quantities. There can be no doubt that there is at

present a great shortage of immediate stocks. Part of this is, of course, due to the fact that you can not carry on business in a period of world-wide war with the same small margin of stocks that is practicable in peace time, but the excess in shipments from England over the receipts and internal consumption toward the end of the year indicate the using up of invisible stocks to a considerable extent.[1]

Costs of Producing Tin

The fluctuations in the price of tin during the past year have resulted in an unusual amount of interest in the cost of producing tin in the various localities. Whatever recent information is available along this line has been included under the various geographical headings.

The prices quoted on tin are, of course, for metallic tin, but the producing companies sell what is commonly termed black tin, or tin oxide, SnO_2, which has no standard value. The price obtainable for black tin depends upon its degree of freedom from impurities, and consequently the output of the alluvial mining fields is generally of better grade than the product from lode mines. As a rough average for calculation purposes, black tin is usually reckoned as being equal to 70 per cent. metallic tin. The average obtained for the Cornish product, as a matter of fact, is probably nearer 65 per cent., but, on the other hand, that of a number of the producers from alluvial deposits is rather more than 70 per cent.

Tin in Foreign Countries

Australia.—There is no doubt that the output from Australia has been very much affected by the war. Receipts in this country and America are lower than last year, being estimated at 1523 tons, as compared with 3240 tons. Probably interference with trade routes is largely responsible for this very large decline. On the other hand, we may note in the case of Queensland that the production for the first 9 months of last year was 1748 tons of black tin, against 3197 tons for the previous 12 months, and Tasmania and New South Wales have also been greatly reduced.[2]

As the result of a conference between miners and directors of the Mount Bischoff Tin Mining Co., and representatives of the government, terms have been arranged for the resuming of work on the Mount Bischoff Co.'s mine in Tasmania. The Minister of Mines (Hon. J. E. Ogden) has stated that in the event of the company being unable to dispose of the ore, the government would come in and make advances upon the value of the ore.[3]

[1] *Min. Jour.*, Jan. 23, 1915.
[2] *Min. Jour.*, Jan. 23, 1915.
[3] *Min. Jour.*, Oct. 31, 1914.

Operations at Briseis, Tasmania, consist in removing a hard and sometimes decomposed basalt overburden, and sluicing the layers of tin drift beneath. The work generally presents some difficulties, one being the tailing disposal and the proximity of the Ringarooma River, which is now being diverted. In 1913 the following was done:

Briseis drift and overburden sluiced, cu. yd.	275,000
Black tin recovered, tons (74.6 per cent. metal)	464.1
Average black tin, lb. per yd.	3.78
Ringarooma or upper drift sluiced, cu. yd.	286,000
Black tin recovered, tons	38.9
Average black tin, lb. per yd.	0.3
Ringarooma overburden removed, cu. yd.	91,900
Total ground moved, cu. yd.	652,900
Total black tin output, tons (74.6 per cent. metal)	515

Cost of recovering black tin and dressing it ready for smelters was as follows:

	Per Ton of Black Tin.
Sluicing, cleaning bottom, overburden cost, etc.	$53.85
Pipes, ditches, elevators, etc.	25.90
Clean-up, dressing, etc.	6.70
Electric light	4.80
Head ditches upkeep	12.96
Stores, timbers, explosives	2.06
Dumping overburden, etc.	40.46
Salaries and office	22.80
Total	$169.53

The cost per ton of metal was $233.50, and the price received for the metal was $875.40 per ton. To this cost of $233.50, should be added $38.60 for freight, smelting, etc., making a total of $272.10 per ton of metal. Moving the hard columnar basalt overburden cost 34.67 cts. per cu. yd. From the sluice-boxes was recovered 56 oz. of gold worth $760.[1]

The Anchor and Australian mines in Tasmania are worked together; the following details of operation are given:

	Anchor.	Australian.
Stone crushed, long tons	76,197	28,525
Black tin saved	134 t. 7 cwt.	63 t. 19 cwt.
Pounds per ton	3.42	5.02
Tons per stamp in 24 hr.	5.38	6.11
Cost	3s. 6d.	3s. 6¼d.

It is only of late years that the Australian mine has been worked, and the average value of the ore for about 10 years at the Anchor mine was 3.42 lb. oxide. As will be seen from the crushing returns (Anchor, 5.38 tons per stamp in 24 hr.; Australian, 6.11 tons per stamp), the Australian stone is easier crushed and resembles the stone from the Anchor some years since, More or less overburden has to be removed, consisting of surface soil and barren granite. The latter is usually decomposed and capable of being hydraulicked, but contains hard masses and seams, in some cases forming 50 per cent. of the material. These have to be blasted and trammed to spoil banks. In some cases this overburden is over 70 ft. deep, and overlies only 30 or 40 ft. of profitable ore.[2]

[1] *Min. Sci. Press.*
[2] J. B. Lewis, *Min. Sci. Press*, July 11, 1914.

China Camp is the name given locally to that portion of the Cooktown District tinfields situated near the Roaring Meg River, about 70 miles by road and 40 miles in a nearly direct line south from Cooktown township. It includes the Lode Hill, Roaring Meg, Bloomfield and China Camp claims.

The Lode Hill claim has during the past 5 years produced a total of approximately 196 tons of tinstone, valued at slightly over £22,000, while the adjoining Roaring Meg property, which has been recently reported as having been acquired by the Lode Hill Co., has, in the same period, been responsible for an additional 86 tons, valued at £10,000, or a total production for the two claims of about 282 tons, valued at approximately £32,000.[1]

Belgian Congo.—Tin mining apparently advanced but little during the year. The Union Miniére du Haut Katanga did nothing at Busanga beyond a small amount of testing, but now that the railroad is opposite the mine, distant some 38 miles, work would have been pushed were it not for the war. The Société Belge Industrielle et Miniére du Katanga's operations at Muika were considerably embarrassed, since, on account of the exceptionally low water in the Luvua River, new machinery did not reach the mine. Early in 1914 it produced about 10 tons of concentrate per month with its 5-stamp mill. The force consists of 11 Europeans and 450 blacks.[2]

Cassiterite is the most abundant mineral in Lower and Middle Katanga, the deposits from a transversal zone extending S.W. and N.E. Up to the present the richest veins are in Bakat, near Muika; good veins have also been found at Kiambi on the Lukusi and near Muanga; also near Mulongo and along the Lukuga railway in the immediate vicinity of the Géomine coal beds. The cost of transport per ton of tin *via* the Congo to Antwerp is £10 2s. 6d. and bagging £8 more. It requires at least 4 months to transfer the tin ore from the mines to Antwerp, where it is sold for £140 per ton.[3]

Bolivia.—Bolivia remains, as usual, one of the enigmas of the situation. The output in 1913 showed an increase of 4663 tons over the preceding year, amounting to 26,048 tons altogether. Bolivian imports into Europe this year are estimated at 18,800 tons, that is to say, 7248 tons below 1913. Shipments since the war began have been very uncertain, and it is impossible to know how much of the decline is due to the inability of obtaining tonnage and how much to the closing of the mines, which was certainly very general when the government proposals for financing the industry failed and the price of tin fell below £130.[4]

[1] *Queensland Govt. Min. Jour.*, Apr., 1915.
[2] M. K. Shaler, *Min. Press*, Mar. 13, 1915.
[3] *Min. Jour.*, July 4, 1914; *So. Afr. Min. Jour.*, Aug. 8, 1914.
[4] *Min. Jour.*, Jan. 23, 1915.

During the first 4 months of 1914 the serious and steady decline in the price of tin caused great anxiety to mine operators in Bolivia, many of whom tried to meet the situation by increasing their production. But when the price fell to £150 and less early in May, several smaller concerns were forced to suspend operations, and the exportation of tin ore declined below the average of the previous year.[1]

When in May, 1914, many smaller mines suspended or reduced operations, more workmen were available, and several of the large concerns reduced the wages of their working forces from 10 to 15 per cent. Then came a slight reaction in the tin market in the first days of July, and hopes again went high, but with the beginning of the great war in Europe everything collapsed. There was no market for tin ore; all credits and consignment contracts were suspended.

The high prices that were paid in New York for tin in August evoked a good deal of enthusiasm, but had, of course, nothing to do with the price of tin concentrates, because nobody would smelt them, and there were no transportation facilities during the first few days of the European conflagration. It was, therefore, suggested that steps be taken by the government or a combination of local mines to build a smelting works in Bolivia. Perhaps the best and most practical argument against it was that the principal mine owner in Potosi, Louis Soux, used to smelt his concentrate in water-jacketed blast furnaces until 1912, the year of the completion of the railroad from Rio Mulato to Potosi. From that time he found it more profitable to ship his concentrate to Europe for smelting.

Some operators, among whom was Señor Patiño, increased their production when it was found that the ore could be regularly shipped to England. All the concentrates from the Uncia and Huanuni mines used to go to Hamburg. More confidence was felt in the future of the tin market when several lots of Bolivian tin concentrates that were stored in Liverpool were sold to the smelters at better prices than anticipated, and representative foreign firms again began making or renewing consignment contracts with the mines, shipping the concentrates to England. Yet the position is far from satisfactory, because the tin ore is not readily sold, but is stored in Europe to abide its time of selling.

Following is a calculation of the value of a ton of 60 per cent. concentrates of good quality, laid down at the station of Machacamarca, on the railroad from Oruro to Antofagasta. Machacamarca has been selected, because this is the point from which nearly half of the Bolivian tin ore is shipped, being the outlet for the mines of Señor Patiño, the Cia. Minera de Oruro, and the Morococala mine of Penny & Duncan.

[1] M. G. F. Soehnlein, *Eng. Min. Jour.*, Jan. 16, 1915.

VALUE OF 1 TON OF 60 PER CENT. TIN BARRILLA

Value of 1 ton of 2240 lb. of 60 per cent. metallic tin (price of tin, £130)...		£78	0s.	0d.
Less smelting charge		12	0	0
		£66	0s.	0d.
Value per metric ton of 1000 kg.		64	19	2
Less commission for marketing (2½ per cent. of value)		1	12	4
Net value of 1000 kg. in Liverpool		£63	6s.	10d.
Deductions:				
Railroad freight, Machacamarca to Antofagasta, about 900 km., B. 64.50 per metric ton	B. 64.50			
Transport to ocean steamer in Antofagasta	4.0			
22 Lobonite ore bags at B. 0.50	11.0			
	79.50 @ 18¾	£6	1s.	7d.
Export duty B. 35.0 @ 19 1-5d		2	16	0
Ocean freight and insurance, Antofagasta to Liverpool		4	0	0
Total		£12	17s.	7d.

Value of 1 ton of 60 per cent. barrilla in Bolivia, $244. U. S. Cy., or £50 9s. 3d.

Smelting charges may vary a good deal; ores containing antimony, arsenic, lead, or more than 1½ per cent. sulphur in the form of pyrites are subject to heavy penalty. Lower grade concentrates from the Potosi district, where generally only 50 per cent. ore is exported, pay as much as £20 per ton for smelting, and the clean ore from Totoral district can be smelted for only £7 per ton. Some smelters adopt a sliding scale of return charges, going up and down with the price of tin. The above example of the charges which a ton of concentrates must bear may, of course, vary considerably. The 2½ per cent. commission for marketing is rather high, and the larger concerns do not pay half so much; as everywhere, it is the small producer that has the largest expense.

In view of the high cost of transportation it would seem a great advantage if the tin content of the concentrates could be raised to more than 60 per cent., and this question has received more attention than in past years when, on account of the high price of tin, mining companies still made good profits. To accomplish this, electro-magnetic separation is being introduced at the leading mines in addition to jig-and-table concentration.

The tin-mining industry of Bolivia is still entirely in the high-grade stage, most of the concentrates being produced from ores with more than 10 per cent. metallic tin; a considerable proportion of the exported ore is hand-picked from the vein matter, without having undergone any treatment. The tonnage worked is small; there are not more than two mills in the country that work over 100 metric tons per 24 hr., and probably the largest does not even crush 150 tons. The Huanuni mine will be the first to work low-grade ore, running from 2 to 3 per cent. metallic tin, on a larger scale, and a 300-ton concentrator is under construction.

The following tables give information concerning the ownership and output of the Bolivian mines:[1]

[1] H. A. Lewis, *Min. Mag.*, May, 1915.

MINES OWNED IN BOLIVIA

Mine.	Department.	Owner.	Monthly Production Concentrate, Cwt. Min.	Max.
Uncia	Potosi	S. I. Patiño	20,000	25,000
Huanuni	Oruro	S. I. Patiño	5,000	8,000
Cerro Rico de Potosi	Potosi	Various	2,000	3,000
Andacaba	Potosi	Quesada Alonso	1,000	2,000
Avicaya	Oruro	Abelli & Cia (Banco Argandoña)	1,000	1,500
Many small mines, alluvial workings, and dumps		Various	1,500	2,000
		Total	30,500	41,500

ENGLISH COMPANIES

Company.	Department.	Monthly[1] Production Concentrate, Cwt. Min.	Max.
Aramayo Francke	Potosi	6,000	7,000
Porco Tin Mines	Potosi	500	800
Royal Silver Mines	Potosi	500	1,000
Berenguela Tin Mines	Cochabamba	300	500
Penny & Duncan (Morococala)	Oruro	2,000	3,000
Duncan, Fox & Co. (Nané)	Oruro	.....	300
	Total.	9,300	12,600

COMPANIES CONTROLLED IN CHILE With Offices in Santiago

Company.	Department.	Monthly Production Concentrate, Cwt. Min.	Max.
Estanifera de Llallagua	Potosi	8,000	15,000
Minera de Oruro	Oruro	2,500	3,500
Minera San José de Oruro	Oruro	800	1,000
Estanifera de Totoral	Oruro	800	1,000
Minera de Colquiri	Oruro	800	1,000
Minera de Monteblanco	La Paz	500	1,000
Minera Oploca	Potosi	2,000	3,000
Minera de Antequerra	Oruro	300	500
	Total.	15,700	26,000

MINES OWNED BY OTHER OUTSIDERS

	Monthly Production Concentrate, Cwt. Min.	Max.
Lower levels in Cerro Rico de Potosi, L. Soux (French)	3,500	4000
Cerro Rico de Potosi, Bebin Hermanos (French)	800	1,000
Huayna Potosi, Dept. La Paz (French)	1,000	1,500
Araca, Dept. La Paz, Harrison & Böttiger (German)	2,000	3,000
Jatuncaca, Dept. Cochabamba, Schlüter & Co. (German)	.....	300
Catorce, Dept. Cochabamba, Mr. Nicolai (German)	100	200
Ocuri, Province Charcas, Mr. Weisser (German)	.....	300
Tucsuhuma, Dept Cochabamba (an Argentine company)	300	500
Total	7,700	10,800

The greater part of Bolivian tin concentrate[1] contains a large percentage of limonite with a specific gravity of about 4. Some investigations made recently in London as to the feasibility of removing this limonite from the concentrate, magnetically, showed that a preliminary roast was necessary, and even then the tailing was very rich in tin. The accompanying table gives the analyses of some lots of Bolivian concentrate amounting to nearly 140 tons. These analyses were made in London, and the tin assays reported were used as the basis on which these lots were sold. The ratio of concentration was over 40 to 1.

[1] H. A. Lewis, *Min. Mag.*, May, 1915.

ANALYSES OF BOLIVIAN TIN CONCENTRATE

Cassiterite.		Oxide of Iron, Per Cent.	Cassiterite and Oxide of Iron together, Per Cent.	Silica, Per Cent.	Copper, Per Cent.	Antimony, Per Cent.	Sulphur, Per Cent.	Total, Per Cent
Sn, Per Cent.	O_2 Per Cent.							
66.0	18.2	11.5	95.7	4.6	0.0	Tr.	Tr.	100.3
64.5	17.8	12.5	94.8	4.0	0.0	0.3	0.5	99.6
64.4	17.8	12.7	94.9	3.9	0.0	Tr.	Tr.	98.8
63.65	17.6	14.0	95.2	4.1	Tr.	Tr.	Tr.	99.3
62.35	17.2	15.0	94.5	3.9	Tr.	0.2	Tr.	98.6
62.2	17.2	15.3	94.7	4.3	0.0	Tr.	1.0	100.0
62.15	17.1	15.5	94.7	4.2	0.0	Tr.	1.0	99.9
62.06	17.1	15.4	94.6	4.0	Tr.	0.3	Tr.	98.9
61.4	16.9	16.4	94.7	3.2	0.0	Tr.	1.0	98.9
61.2	16.9	18.1	96.2	3.7	Tr.	Tr.	Tr.	99.9
61.0	16.8	17.0	94.8	4.4	0.0	0.4	Tr.	99.6
60.75	16.8	15.5	93.0	4.7	Tr.	Tr.	1.0	98.7
60.7	16.7	17.0	94.4	3.7	Tr.	Tr.	1.0	99.1
60.45	16.7	17.5	94.6	3.7	Tr.	Tr.	1.0	99.3
60.35	16.6	17.0	93.9	4.5	Tr.	Tr.	Tr.	98.4
60.2	16.6	18.0	94.8	4.0	Tr.	Tr.	1.0	99.8
60.2	16.6	18.0	94.8	3.8	Tr.	0.2	0.35	99.1

The Berenguela tin district[1] is situated roughly half-way between the towns of Oruro and Cochabamba. A branch railway is being constructed between these two towns, and the rail-head is now at Arque, slightly over half-way to Cochabamba. The nearest point to the mines is Colcha, a village at the foot of the Berenguela mountain, 2500 to 3000 ft. below the mines and about a league from most of them.

The lode formation, as might be expected in sedimentary beds, shows considerable irregularity of outline and has been largely modified by the faults and fissures formed at the time of the lateral squeeze. A usual type of fissure is that which has the form of a Z, or a series of them. The angles, however, are more often obtuse then acute. When the plan of a lode shows this form, a large deposit of ore may be expected at the bends and for some distance therefrom. Another type of lode is that in which the section shows this Z form of fracturing on the hanging wall. Here we may look for trouble. The lode will be erratic and unreliable, and further prospecting will disclose the fact that the only places in which profitable mineral is to be expected are immediately under these overhangs of the hanging wall. The other lodes of the district are of normal type and call for no special comment.

Operations, as is usual in Bolivia, consist of mining by adit. A cross-cut is run to the lode, which is then followed in the usual way and the necessary ore-passes made. Close to the mouth of the main adit a ropeway is installed to take the ore to the mill, which is generally placed at a much lower level.

Where the veins are narrow and the country rock sound, methods are normal and require no comment. Some of the principal lodes, however,

[1] H. A. Lewis, *Min. Mag.*, Dec., 1914.

are wide, at any rate in parts, and the hanging walls are bad. When such lodes dip at about 45°, the question of extracting the ore becomes a matter for careful consideration. Any sort of effective timbering is out of the question.

The principal mines of the district are Berenguela, Tucsuhuma, Jatunkaka, Empresa Hornuni, and Leque; there are numerous other small prospects. Of these, Berenguela and Tucsuhuma have been producing for some years with the aid of machinery. Jatunkaka has been devoting attention to development while maintaining a small production of *barilla* with hand appliances. A modern mill is now being erected. Empresa Hornuni has a peculiarly arranged mill and a mine that is not opened up, but is well regarded by the miners who have worked there. The mill is driven by a portable steam engine. As fire-wood, delivered at Hornuni, costs B. 3 per quintal of 100 Spanish lb., the plant can be run only at a loss. *Taquia* (llama dung) and *yareta*[1] (a species of moss) are not available in this district. Leque is a promising prospect, producing a few quintals of *barilla* each month by hand appliances.

It is perhaps hardly fair to describe too minutely the methods of tin dressing employed at the moment in this district, for the reason that both the mill at Berenguela and that at Tucsuhuma are undergoing improvements.

The Berenguela mill consists of ten 650-lb. stamps, in steel frames (which are unsatisfactory), two trommels, one 2-compartment Harz jig, one Wilfley and one Buss sand table, one 3½-ft. Huntington mill for re-grinding, two 6-ft. vanners and two 4-ft. vanners, besides several square and round buddles for cleaning concentrate. The Huntington is not running, and two revolving decks for the treatment of slime are yet to be put in operation. Hydraulic classifiers are to be substituted for the trommels, and large conical de-waterers are being installed.

Power is furnished by two 20-h.p. Sulzer Diesel engines with a 12½-h.p. Hornsby-Ackroyd in reserve. These Diesel engines burn, roughly, 20 gal. of kerosene each per 24 hr.

The Tucsuhuma mill consists of two ball mills (one in reserve), hydraulic classifiers, one Harz jig, three Humboldt sand tables, two overhung vanners, and one revolving deck, besides settling tanks and pumps for return of wash water. Power is furnished by one 20-h.p. Sulzer Diesel engine with two 8-h.p. two-cylinder Deutz oil engines in reserve.

Particulars as to the new mill just begun at Jatunkaka are not yet available, although it will be probably more complete than either of the above, as is to be inferred from the fact that two 30-h.p. horizontal Diesel engines are being supplied.

[1] *Min. Mag.*, December, 1913, p. 451.

The scale of wages ruling in the Berenguela district is as follows: Transport of *barilla* to Oruro is effected by llamas, the cost per quintal of 100 Spanish pounds being B. 2. A llama will carry 1 quintal (21.7 Spanish quintals is a close approximation for a metric ton). A close approximation for the cost of concentrate, assaying 60 per cent. tin, from the mines of this district until sold in London, including all charges whatsoever, is £36 per ton. With tin at £130, a ton of 60 per cent. *barilla* is worth £78; therefore, the margin is £42 to cover mining, milling, repairs, depreciation, office, overhead, and any other charges. It is clear that £130 for tin is pretty close to the limit, below which most Bolivian mines will fail to pay expenses.

Although this district has been kown from ancient times, it can be said that little is yet ascertainable as to its ultimate future possibilities. In general, it can be said that the more the different properties are explored the more encouragement is obtained to pursue investigation. One noteworthy feature is that all these mines or prospects are situated on one hill and within a relatively small area. The railway is at the foot of the hill. There are two main streams at the foot of the mountain, either of which would be capable of furnishing 150 h.p. per km. There is, therefore, plenty of hydraulic power available in the district.

As in all tin mines, the future will depend on the ore encountered in the sulphide zone. The lowest working in the district discloses pyrite richer in cassiterite than the oxidized ore at present being mined. It would seem, therefore, that some day all the mines will become one concern, united by ropeways to a central mill alongside the railway, and that hydro-electric power will replace the small individual Diesel units. The scale of operations would be increased many times and the cost of production would be one-half of that at present obtaining.

EXPORTATION OF TIN ORE FROM BOLIVIA
(In metric tons)

Year.	*Barrilla.* Tons.	Tin Contents. (*a*)	Year.	*Barrilla.* Tons.	Tin Contents. (*a*)	Year.	*Barrilla.* Tons.	Tin Contents. (*a*)
1901..	21,573	12,943	1907.	27,678	16,607	1913...	44,594	26,756
1902..	17,340	10,404	1908.	29,938	17,963	1914...	34,624	20,744
1903..	21,785	13,071	1909.	35,566	21,340	.....	.....	.....
1904..	20,369	12,221	1910.	38,548	23,129	.....	.....	.....
1905..	27,690	16,614	1911.	39,841	23,904	.....	.....	.....
1906..	29,370	17,624	1912.	38,614	23,168	.....	.....	.....

(*a*) Tin content of the barrilla (black tin concentrate), computing the latter at 60 per cent. metallic tin.

While the official figures arenot available, the approximate exports of tin from Bolivia during 1914 were as follows: January, 3783 metric tons; February, 3216; March, 3665; April, 3477; May, 3461; June, 3505;

July, 3426; August, 1490; September, 1872; October, November, and December, 6729 tons. Separate figures for the last 3 months of the year are not available. The average exports of these 3 months (2243 tons per month), as compared with the average for the 7 months preceding the outbreak of the European war (3505 tons), show a falling off of but 36 per cent.[1]

China.—From China there is, as yet, no detailed information. The arrivals in Great Britain and the United States, however, are given as 1824 tons, against 2337 tons in the previous year, and it is probable that Yunnan, which is practically the sole source of supply, was severely affected by the war and dislocation of trade.

According to Consul General Geo. E. Anderson, of Hongkong,[2] there has been considerable trouble in tin-importing circles in the United States and Europe as to the comparative purity of tin shipped to those markets, both from Singapore and from Hongkong.

At times, when tin from Yunnan and Kwangsi has been of unusually low grade, some Straits tin has been imported to bring the quality of Hongkong smelted Chinese tin up to the usual Hongkong standard for export to the United States and Europe, but this has been done rarely and under special circumstances.

During recent years the standard qualities of tin exported have been No. 1, ranging from 99 to 99½ per cent. pure; No. 2, ranging from 98 to 98½ per cent. pure; and No. 3, ranging from 96 to 96½ per cent. pure. At present the standard qualities quoted are: No. 1, ranging from 99 to 99.4 per cent. pure; No. 2, ranging from 98 to 98.4 per cent. pure; and No. 3, ranging from 96 to 96.4 per cent. pure. Apparently much of the trouble had by American importers with tin shipped under this grading and classification not coming up to the standard sold and marked has been the result of substitution by unscrupulous dealers of lower grade tin for that analyzed and passed by the government analyst here.

The export of tin from the South China fields[3] through Hongkong in 1914 fell off over one-third as compared with the exports of the previous year, although the opening months of the year showed exports which promised a record year. The total amount of the metal received from the Yunnan mines by the Hongkong refiners aggregated about 8000 tons, of which something more than one-fourth was exported to China coast ports for various industries. The figures of the Hongkong General Chamber of Commerce indicate the distribution of the rest of the exports from Hongkong for the year as compared with those of last year, as follows (in slabs of 112 lb.):

[1] *Comm. Rept.*, Mar. 23, 1915.
[2] *Daily Cons. and Tr. Rept.*, May 26, 1914.
[3] *Comm. Repts.*, Feb. 17, 1915.

Destination.	1913.	1914.
Great Britain	8,047	5,644
Continental Europe	32,575	20,892
United States	36,790	24,699
Total exports	77,412	51,235

The above figures are not given as conclusive, as no government record of exports or imports is kept in Hongkong, but they illustrate the course of the trade. The course of exports has been determined almost altogether by the course of prices in the United States, exchange and all considered.

The tin deposits[1] so far discovered in the Fu Chuan district of South China are all alluvial, and lie scattered over a range of these granite mountains for a distance of more than 30 miles. The average latitude of this range is about 2500 ft. It is flanked by limestone, which forms foothills, and in many places along the contact has been changed to a pure white marble. The cassiterite is found in the streams which come down from the hills, but most of it comes from the hillsides, where it lies in the cuplike depressions of the limestone, and can be easily gained without the removal of much overburden or interference from water. The natives dig it out of these pits, which in extreme cases are 30 ft. deep, but generally much less, and carry it in baskets to the nearest stream, where it is washed in short sluices.

The ground worked by the natives yields cassiterite from 3 lb. per cu. yd. up. It is free from clay and boulders, and is ideal ground to wash. No veins have yet been found.

Up to the present the industry has been conducted as a provincial government monopoly. The government has established stations at the various localities where tin is being washed, where the concentrate is bought from the native, smelted and marketed. The government itself does no mining. Any person can start mining without any formality whatever, but he is obliged to sell his product to the government station. The price paid is generally fair, varying from 12 to 16 cts. gold per lb. of 70 per cent. concentrate. This would be a most unreliable figure to count on, however, should a company commence producing tin on a large scale.

Under the new mining laws of China, which have just been issued (April, 1914), it is doubtful what will become of this monopoly, since no provision seems to have been made for it. It deserves to pass out of existence, as it is undoubtedly holding back the proper development of this promising field.

[1] M. B. Yung, *Bull. Amer. Inst. Min. Eng.*, Sept., 1914, p. 2451.

The smelting is done by contract, the smelting contractor guaranteeing 64 per cent. of tin bullion out of the clean concentrate he receives, and his profit is wha the can make over and above this amount.

The tin bullion generally assays over 98 per cent., and is used by the refiners in Hongkong to improve the grade of the Yunnan tin. The yearly output is about 150 tons of tin bullion.

Dutch East Indies.—As regards Banka and Billiton the position is also indefinite. No public sales have been held in Holland since September 3, and at the end of the year no information was forthcoming as to when these sales would be renewed. The government does not sell ore at Singapore, but for the time being is anxious to sell at Batavia. The Billiton Co. sold 2252 pikuls in November at Batavia, and 7515 pikuls in December about equally between Batavia and Singapore. No reliable information is available as to the scale of work being done either on the government or the Billiton Co.'s mines. At the least it may be said that some reduction is practically certain, if only from the experience of every other tin-mining field. No data are available as to whether any tin was shipped to Holland in the last 2 months of the year. The stocks at the end of December in the Netherlands Trading Co.'s hands were 3386 tons, or rather more than double the figure of the previous year. This figure was about the same as at the end of October and November, though, of course, it is impossible to know how much tin has been disposed of privately. The supplies of Banka and Billiton for last year were 9458 tons, against 14,522 tons in 1913, a decrease, that is, of 5064 tons. As against this, the stocks have, as we see, increased 2176 tons, so that there appears to be a net decrease at the moment of 2888 tons. The possibility that the shortage in the supplies of Dutch material would be only a temporary relief to the market, and would be bound to come upon it before long, was a strong factor in retarding any advance in price in the autumn. However, the market has now gotten used to the idea, and as the published stocks show no indication of increase, it is being more generally recognized that the decrease in the supply must be regarded as a real factor.[1]

Federated Malay States.[2]—The mining industry of British Malaya passed through an eventful period in 1914, as the war put a temporary stop to the buying of tin ores, and with the large Chinese population in the country the possibility of the wholesale closing down of the industry gave rise for a brief period to grave anxiety. However, the government came forward with promises of help, and in a very short time the industry resumed its ordinary appearance, so much so that at the end of the year

[1] *Min. Jour.*, Jan. 23, 1915.
[2] *Min. Jour.*, May, 1915.

output showed only a very small decline on the figures of the preced- year, and was actually larger than that of 1912. The following table ws the totals and the respective contributions of the various states:

	1913. Long Tons.	1914. Long Tons.	
Perak	29,403	28,557	− 2.87 per cent.
Selangor	15,406	15,103	− 1.96 per cent.
Negri Sembilan	1,885	1,697	− 9.9 per cent.
Pahang	3,433	3,685	+ 7.3 per cent.
	50,127	49,042	

ese figures are the more noteworthy in that the prices obtained for the tal were much lower. The average price in 1913 was $99.57, as against .44 in 1914, in fact the highest price reached was actually lower than the rage in the previous year. Although the output of tin showed great sting power to these depressing figures, there was a feature which, earlier days at any rate, was a well-recognized signal of a coming de- ie in production, and that was a decline of 24 per cent. in the number Chinese engaged in mining. These figures, however, no longer possess te their past significance because of the rapid increase which is taking ce in mechanical power, more particularly oil and gas engines, and the spects of the completion of several hydro-electric installations. The

PRODUCTION OF TIN IN THE FEDERATED MALAY STATES (*a*)

(In pikuls of 133⅓ lb.)

	1906.	1907.	1908.	1909.	1910.	1911.	1912.	1913.	1914.
k	435,909	431,386	467,784	461,665	421,335	437,339	.....	493,972	479,758
ngor	268,624	273,900	282,540	266,007	240,192	231,175	.....	258,822	253,730
ri Sembilan	77,766	75,155	64,221	48,072	34,697	29,230	.....	31,668	28,510
ng	34,488	33,195	39,520	43,144	40,674	43,954	.....	57,674	61,908
							.....		
l	816,787	813,636	854,065	818,888	736,898	741,698	813,472	842,136	824,106
ric tons	49,859	48,411	51,654	49,529	44,579	44,870	49,215	50,946	49,855

a) Exports of tin ore, the latter being calculated to its assumed metal contents, upon which duty id to the F. M. S. government.

FEDERATED MALAY STATES' TIN OUTPUT (*a*)

	1910. Pikuls. (*b*)	1911. Pikuls. (*b*)	1912. Pikuls. (*b*)	1913. Pikuls. (*b*)	1914. Pikuls. (*b*)
uary	66,277	64,333	67,566	69,232	83,711
ruary	64,199	53,147	72,545	64,219	59,725
rch	46,850	50,132	53,698	59,842	64,508
il	60,020	54,568	67,270	68,305	68,655
y	61,935	62,868	71,849	72,563	69,471
e	62,180	64,202	59,465	67,078	72,275
y	65,350	63,799	71,175	71,318	76,985
ust	70,639	68,592	74,831	77,613	60,330
tember	56,324	62,862	69,133	73,574	60,869
ober	60,444	68,764	65,605	74,080	65,656
vember	61,771	66,334	69,087	66,790	(*d*)63,639
ember	60,909	62,091	71,248	77,522	(*d*)63,206
Totals	(*c*)736,898	(*c*)741,698	(*c*)813,472	(*c*)842,136	809,030

(*a*) From *The Mining Journal*. These figures show the monthly exports of tin and tin ore (the r being stated at its assumed metal content) upon which duty is paid to the F. M. S. Government. 1 ton (2240 lb.) = 16.8 pikuls. (*c*) Finally revised figures. (*d*) Exclusive of Pahang, etc.

Tanjong Rambutan Company's pipe line was brought into use, and progress made with the Gopeng Consolidated new line. Last year mechanical power to the extent of 5000 h.p. was brought in, which is estimated to be roughly equivalent to something like 40,000 coolies. The conditions of the industry led to a decline of 38 per cent. in the men working on contract, and of 37 per cent. on wage men. Those working on tribute, however, were reduced only 10.8 per cent., and this feature corresponds to the experiences of tin mines in Australia and Tasmania. As regards the differenct classes of mining, the following labor figures may be of interest:

	1913.	1914.	
Open-cast	167,669	124,015	− 26.0 per cent.
Underground	20,454	14,793	− 27.0 per cent.
Hydraulic and lampan.	36,681	32,373	− 11.2 per cent.
Bucket dredging	.....	508	

A marked feature of the increased use of machinery is the growing popularity of the bucket dredge. In addition to the plants of the Malayan Tin Dredging Co., dredges for the following companies were under construction at the end of the year: the Tronoh Mines, the Ipoh Tin Dredging Co., the Kamunting Dredging Co., the Kampong Mamnuting Dredging Co., and the Chenderiang Tin Dredging Co. Many of the Chinese-managed mines now have considerable power plants, and it is interesting to note that the proportion contributed by these enterprises increased from 74 to 76 per cent. of the total output.

The effect of the crisis in the tin market, due to the war, was to further strengthen the position of the two big European smelting companies—the Straits Trading Co. and the Eastern Smelting Co.—for the amount exported as ore increased from 756,626 pikuls to 762,730 pikuls, while the metal smelted was only 61,179 pikuls, compared with 85,502 pikuls. Of the small local smelters there were 11 in operation during the year, mostly in Perak.

Lode mining appears to have made some slight progress during the year, but the large capital required is felt to be an obstacle at the present time. The output of the Pahang Consolidated was the largest in the country, amounting to 2496 tons. Unfortunately, the company has since had some trouble with its plant, which has temporarily affected output in the new year. The company installed a considerable amount of new plant during the year, including pumps, turbo-alternator, James' sand tables and slime tables, and Dorr thickeners. The Titi Mining Co. produced 8300 pikuls of tin and 1600 pikuls of wolfram; they are working three lodes; the Semedah lode at 100 ft., the Main lode at 60 ft. below adit, and the Rin lode at 100 ft., with old workings cleaned out 50 ft. lower. The Sungei Grau, in Pahang, milled 4914 tons for an average extraction of 2.88 per cent. This mine is equipped with Wilfley tables,

a slime table, and hydraulic separator and sizer. Another small mine, the Chin Chang, milled 8466 tons for a yield of 1.56 per cent.

The cost of production of those companies dredging for tin in the East and elsewhere is of interest in this connection, as dredging is one of the cheapest methods of production. Very few dredging companies publish their costs with the monthly returns, but the Malayan Tin Dredging Co. is an exception. Analyzing the return published recently, we get the following: Treating 100,500 yd., obtained 31 tons of tin ore, value £2500, costs £1500. The net price obtained for the ore was roughly £81 per ton (approximately 60 per cent. of metallic tin), all charges and duty being deducted. On the same basis, if metallic tin was quoted as low as £85 per ton, and 60 per cent. was obtained for the tin oxide, equal to £51 per ton, the value of the 31 tons would have been £1581, leaving a profit of £81. The costs are roughly 3½d. per yd. and the profit 2½d. per yd., even at the present low price of tin.[1]

Shipments of tin to America during 1914 amounted to 22,032,267 lb., as compared with 26,222,133 lb. in 1913.[2]

Great Britain.[1]—The year has been a very difficult one in Cornwall, and there is, unfortunately, no promise that the output will not show a further decline in the coming year.

The sales of tin concentrate at the ticketings during 1914 amounted to 4987 tons, selling for £432,437, or an average of £86 14s. 3d. per ton. During the previous year, 6186 tons brought £744,268 or £120 2s. 6d. per ton, and during 1913, the sales were 6492 tons bringing £831,809 or £128 5s. 6d. per ton. In spite of the fall in the price of tin, and the suspension of sales from July 20 to September 21, owing to the absence of a market for the metal, the results of the year's work are far from discouraging. Moreover several of the mines, notably Dolcoath and South Crofty, have stocks of unsold black tin, waiting for more settled conditions. The only mine to show an increase during the year was East Pool, the improved position being due to the new capital introduced by Bewick, Moreing & Co. Dolcoath sold 1137 tons, East Pool 600 tons, Carn Brea & Tincroft 527 tons, Grenville 517 tons, South Crofty 466 tons, Bassett 419 tons, Levant 394 tons, St. Ives Consolidated 278 tons, and Wheal Kitty 235 tons. Wheal Kitty does not sell at the ticketings, but by private contract.[3]

The cost of producing a ton of black tin varies considerably in various mines, the main essential for cheapness being the richness of the ore for cassiterite. Naturally the methods employed for extracting the valuable products from the ore, as also the winning of the ore itself, take

[1] *So. Afr. Min. Jour.*, July 4, 1914.
[2] *Comm. Rept.*, March 31, 1915.
[3] *Min. Jour.*, Jan. 23, 1915.

a certain bearing in relation to the cost of production, but the primary consideration is the value of the ore for SnO_2, and as this appears to be decreasing, the probability is that our costs will rise correspondingly. In mines such as South Crofty and East Pool the absolute cost for the black tin product is not readily obtained. Their costs cover also the winning of a certain amount of wolfram and arsenic, so that differentiating the costs for either product is scarcely possible. Dolcoath and Grenville mines during the first 6 months of 1913 produced 786.96 and 348.91 tons of black tin, respectively, the former for a working cost of £95 4s. 3d. per ton, while the latter's figure was £92 8s. per ton. Dolcoath expended (including depreciation) £75,600 in the second half of 1913 and sold slightly over 738 tons of black tin. Thus the cost was £102 per ton, of which lords' royalty represented approximately £7 per ton. The "all in" costs of the Cornwall Tailings Co., of course, are considerably less than those of the Dolcoath mine, having been reduced now to about £60 per ton of black tin; this concern, therefore, is still making a fairly good profit.[1] Bassett mine during the whole of 1913 produced 574.67 tons of black tin at a cost of £111 13s. 10d. per ton. To date for this year Dolcoath has sold, per ticketing papers, 643 tons of black tin for an average price of £94 17s. 7d. per ton. Grenville has sold 285 tons for an average price of £93 12s. 4d., and Bassett, 223 tons for an average price of £89 15s. Taking these figures as a basis, we may calculate that, whereas Grenville has made an average profit of 24s. 4d. per ton for each ton sold this year, Dolcoath has made a loss of 6s. 8d. per ton, and Bassett a loss of £21 18s. 10d. per ton for each ton sold.

Nigeria.—Production was very large in the early months of the year, but the steady decline in prices during the spring and early summer induced some of the companies to close down and wait for better times. The shipments to England, which are our only measure of the output and up to the end of the year, at any rate represented, all the shipments made, amounted to 6453 tons, compared with 3880 tons for 1913. Converted into metal at 70 per cent. these shipments represent respectively 4517 tons and 2716 tons, an increase of 1801 tons. The outlook in Nigeria is not by any means clear, and much will depend on the future course of prices. While the Colonial Office did not feel disposed to offer the assistance which was forthcoming to the Malayan industry, it did reduce the rate of royalty, which, instead of being 5 per cent. of the gross, is now on a sliding scale varying from 2 to 5 per cent. as the price of tin ranges between £130 and £190 per ton. The through rate on tin ore on the Nigerian Railway was also reduced to 3d. per ton per mile. These reductions were only made temporarily, and it remains

[1] *Min. Jour.*, Jan. 23, 1915; June 20, 1914. *So. Afr. Min. Jour.*, June 20, 1914.

to be seen whether they will be continued after the end of March. A difficulty which some of the companies feel very keenly is the refusal of the Colonial Office to grant any more mining leases, as the official surveyors are occupied on military duties. As some companies would no doubt start producing from fresh ground as soon as leases were granted to them, and some of the older leases are now becoming worked out, it is clear that the Colonial Office policy may considerably affect the output in the coming year, and until we know what it is, forecast is difficult.[1]

The most complete official figures on which to base an estimate of the cost of Nigerian tin are those of the Bisichi, which has given its "all in" cost for 1913 as £87 per ton, while at the annual meeting the Chairman foreshadowed a reduction to about £80 per ton this year.[2]

Siam.[3]—A feature of the tin-mining industry which centers around the Straits is the increased production obtained from Siamese Malaya and Siam itself. Nowhere has the tin-dredging industry had so much success, and the scale of operations at the present time is the most extensive anywhere. For the last financial year, 1913–1914, eight dredges were at work, which produced black tin yielding 1800 tons of metal from 4,700,000 yd. of gravel treated. This number has been added to since, and there are now 13 dredges at work and more under construction. Apart from the dredging industry, the output of metal would probably show a declining tendency. The output for the last 4 years in metal is as follows:

1910–1911	4900 tons.	1912–1913	6600 tons.
1911–1912	5900 tons.	1913–1914	6800 tons.

Straits.—The shipments from the Straits were 65,240 tons, compared with 64,608 tons last year, an increase of 632 tons. The tendency

STRAITS SHIPMENTS OF TIN[4]

	1910, Tons.	1911, Tons.	1912, Tons.	1913, Tons.	1914, Tons.
January	5,872	4,315	3,997	5,949	5,327
February	4,174	4,290	5,256	4,666	6,527
March	2,858	4,491	5,142	4,814	4,118
April	4,025	3,115	4,235	4,301	4,914
May	4,977	4,311	5,753	6,176	6,899
June	4,117	5,057	4,302	4,824	5,877
July	5,047	4,553	4,381	4,793	5,100
August	5,705	4,675	5,366	6,011	3,480
September	4,218	5,163	5,475	5,152	5,100
October	4,476	4,371	4,422	5,015	3,785
November	4,856	4,841	5,642	5,662	5,709
December	4,296	5,994	4,996	5,105	6,404
*Sundries	1,494	1,873	2,790	2,140	2,000
Totals	56,115	57,049	51,757	64,608	65,240

* To India and China

[1] *Min. Jour.*, Jan. 23, 1915.
[2] *So. Afr. Min. Jour.*, July 4, 1914.
[3] *Min. Jour.*, Apr. 24, 1915.
[4] *Min. Jour.*, Jan. 16, 1915.

no doubt this year has been to sell more metal in the Straits, and the increase in the Straits shipments, which is after all very small, seems accounted for by a transfer in business and not by new supplies.

The largest of the Straits tin producers is the Tronoh, and this undertaking's expenditure in 1913 (including the depreciation allowance and £99,000 paid for ore purchased) totaled £221,300, while 2187 tons of tin oxide were sold. The cost, therefore, was £101 per ton of tin oxide sold. If allowance be made for sundry receipts, amounting to £13,118, the net cost works out at just over £95 per ton. The Tekka, another Straits producer, expended £19,700 last year and sold 358 tons, so that in this case the cost was just over £55 per ton.[1]

South Africa.—South Africa has suffered, like every other field, and though November showed considerable recovery, it is quite likely that the effect of the war may be seen again in the December returns. The total for the 11 months was 3505 tons of black tin, as compared with 3672 tons for the whole of 1913, which should give with the December return, still to come, practically the same figures for the full year.[2]

Most of the South African production comes from the Transvaal, as is shown by the following production figures from this province:

	Tons.
1911	3525.6
1912	2932.6
1913	3600.4

The ore-dressing plant recently erected at the Leeuwpoort mine[3] is undoubtedly the last word in tin-mining equipments in this country—probably in the whole tin-mining world. A tin-dressing plant is necessarily complicated, more especially when designed to treat entirely dissimilar ores from the numerous occurrences or mines on the Leeuwpoort property. Some of the ore is fine grained, some coarse, and some contains a large proportion of either iron oxide or sulphide.

The mill and concentration plant occupy an ideal site on the slopes of a hill, about midway between the main workings. Provision has been made for extension at any time. The sorting and crushing station has a belt conveyor system, with Lea's washing trommel for fines and coarse, including picking belt feeding direct to mill bin conveyor. The reduction and concentrating plant consists essentially of 15 Californian stamps (1250 lb. falling weight) and two Nissen stamps (1500 lb. falling weight), having a common King Post with five head of the Californian stamps. The concentrating plant includes Harz jigs, R. J. classifiers, Buss and Wilfley tables, Isbell frue vanners, Dorr thickener, rag frames, round frames, together with tube mill, Huntington mill, and Brunton calciner. An

[1] *So. Afr. Min. Jour.*, July 4, 1914.
[2] *Min. Jour.*, Jan. 23, 1915.
[3] *So. Afr. Min. Jour.*, July 4, 1914.

automatic slimes sampler has been installed for taking hourly samples of slimes tails. An Elmore pulp sampler has been erected for sampling battery pulp.

Owing to the comparative fineness of the disseminated cassiterite, and lack of "free" tin, fine crushing has had to be resorted to, which naturally increases sliming and consequently the subsequent concentration difficulties. As the ore becomes more pyritic with increasing depth, additional roasting and re-grinding plant, together with the necessary concentrating units, will be required. The special features in connection with the tin-dressing plant are: (1) The provision of efficient and very complete classification in series before concentration (in the form of Richards-Janney classifiers) for both Wilfley and Buss, and also frue vanner feeds; (2) adequate primary treatment of fines, slimes, after classification, on Isbell frue vanners (10 in number), with rag frames, round frames, and Acme tables as secondary concentration only; (3) the installation of a notably short tube mill, employed for re-grinding the bulk of the middlings, with a secondary re-grinder (Huntington mill) for separate higher grade middling products, to bring sliming and consequent losses to a minimum; (4) installation of a Dorr thickener as a more efficient and economical de waterer than a number of separate small units scattered about the mill; (5) the installation of two Nissen stamps in connection with the Californian stamps (both of comparatively light weight).

It has been an open secret for some time past that at certain of the Waterberg tin mines the presence of iron (both as hematite and magnetite) in close association with the cassiterite has been a big hindrance to effective concentration. It is stated that at one mine in the area referred to above, magnetic separation has been tried, but for some reasons which are not at present very clear this method has so far been unsuccessful. With a view to separating the tinstone from the intimately associated ores of iron, Mr. E. Kenyon, an experienced mill and concentrator man, has recently devised a method from which good results are expected. The Kenyon method of finally dressing tin ores consists in the main in grinding the ore coarsely and then passing the pulp over a series of seven concentrating tables fitted with riffles. Mr. Kenyon's idea is to avoid the creation of slime, and he contends that by means of this method separation of cassiterite from the closely associated iron ores can be effected without difficulty and at very moderate cost.[1]

The working profit of Swaziland Tin, Ltd., for the year ending June 30, 1914, was £8400, as against £24,729 for the previous year, the decrease being due to the severe drop in the price of the metal and to the

[1] *So. Afr. Min. Jour.*, Jan. 31, 1914.

lower grade of gravel treated during the year. A comparison of the year's results with those of the previous year is as follows:

	1913–14.	1912–13.
Cu. yd. treated during year	722,014	408,349
Cu. yd. treated, average per month	60,168	34,029
Lb. concentrate recovered per cu. yd	1.178	1.833
Grade concentrate per cent. metallic tin	71.9	71.7
Lb. metallic tin per cu. yd	0.847	1.314
Average value per cu. yd	1s. 0.584d.	2s. 2.214d.
Average cost per cu. yd	9.792d.	11.681d.
Average profit per cu. yd	2.792d.	1s. 2.533d.

These figures show that the amount of ground treated during the year was 76 per cent. more than during the previous year and the cost of working per cu. yd. 16.2 per cent. less; but, as the price realized was 25.5 per cent. less and the grade of ground per cu. yd. 35.5 per cent. less than during the previous year, the profit was greatly reduced. This company has a total of 2,056,266 cu. yd. of profitable ground proved by boreholes ahead of present workings, showing an average value of 1.47 lb. of metallic tin per cubic yard, with an estimate of 10,000,000 cu. yd. of tin-bearing ground, in addition to that already proved.

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TITANIUM

By James Aston

The only titanium produced in this country in 1914, so far as reported by the U. S. Geological Survey, was, as heretofore, that put out by the American Rutile Co. at Roseland, Nelson County, Va. The company produced 94 tons of rutile, carrying 95 per cent. of titanium dioxide, and as a by-product, 89 tons of ilmenite carrying about 55 per cent. of titanium dioxide. The sales included a quantity of rutile left over from 1913 equal to the production of 1914. The company did not operate its mill in 1914 until the middle of August. During the earlier part of the year the mill was thoroughly overhauled and new stamps and other machinery were installed. Large foreign orders could not be filled on account of the effect of the war upon commerce.

The rutile-bearing rock, which is termed syenite by Dr. T. L. Watson, State Geologist of Virginia, but which shows decidedly pegmatic phases, is worked in open cuts by the company. Most of the rock worked came from a bluff near the mill, on the east side of the Tye River, but some of the rock was also taken from the west side of the river. The rutile forms about 5 per cent. of the rock worked.

Rutile is used in electrodes for arc lamps, for making ferro-titanium for use in iron and steel, and in ceramics and chemicals. Concentrated rutile sells for $50 to $400 a ton, depending on quality, quantity, and preparation.

The rutile deposits of eastern United States are described by Dr. Watson,[1] and for the sake of comparison, discussion of several foreign deposits is included. While rutile has a very broad distribution, it is but rarely found in large quantities, and the known deposits of commercial value are few and widely separated, being limited to three localities in North America and one each in Europe and Australia. The commercial localities include: (1) the Amherst-Nelson and Hanover-Goochland areas in Virginia; (2) Bay St. Paul in northern Quebec, Canada; (3) Kragero, in Norway; (4) an area near Mount Crawford, 25 miles northeast of Adelaide, South Australia.

The rutile is found in igneous, metamorphic and sedimentary rocks, and occurs as microscopic inclusions in the rock forming silicate minerals,

[1] *Bull.* 580, U. S. Geol. Surv.

and as separate formless grains and masses of variable size. The latter form of occurrence is least common, but is the only one of economic importance.

While of secondary interest as far as their utility as sources of titanium metal is concerned, the experiments concluded during 1914 on the smelting of titaniferous iron ores are of primary importance in their bearing upon the utility and smelting properties of ores of this character. The object of the work has been to determine to what extent the vast deposits of titaniferous iron ores of the Sanford Hill district in New York state could be concentrated and successfully smelted into marketable pig iron. It was hardly to be expected that the high titanium content of the ore would appear in large part in the resultant pig iron, and confer an added value. On the contrary, the problem was one of economical smelting of the ore, with the elimination of the greater part of the titanium in the slag, and the production of a pig iron, with or without titanium content, which could be put into the market in direct competition with the customary grades. For foundry or other special purposes, there might be some advantage in the titanium content, and a somewhat enhanced value of product because of it. But for such tonnage as might be used for steel making, the titanium content would have no value, because of its elimination in the steel manufacturing process.[1]

The ore of the Sanford Hill deposit is a mixture of ilmenite, the non-magnetic titanium-bearing portion, and magnetite. Magnetic concentration is feasible or not, depending upon the state of aggregation of the mixture. Where the mixture of minerals becomes very intimate, no amount of crushing or preliminary preparation will result in a material of suitable concentration of magnetite in the heads and ilmenite in the tails. A typical analysis of the ore is: Fe 47.47 per cent., Ti 12.61, (TiO_2 21.02), SiO_2 5.18, Al_2O_3 4.20, P 0.018 per cent. After concentration, a representative product showed Fe 54.11 per cent., TiO_2 13.78, SiO_2 2.50, Al_2O_3 4.60 per cent., P trace. The degree of concentration varied somewhat with the ore and the type of concentrator used, and the titanium oxide varied from 12 to 14 per cent.

The experiments were in charge of F. E. Bachman, manager of the Port Henry furnace of the Northern Iron Co., the furnace being leased to the MacIntyre Iron Co. for the period of test.

The plan in smelting was to commence with a charge of 1/16 titaniferous ore, and to increase gradually to a proportion of 5/16. The balance of the ore charge consisted of the normal non-titaniferous ore of the district. Smelting was begun on Feb. 3, 1914, and 1/16 titaniferous ore was used for 3 days; the ratio was then changed to 1/8 for 7 days. Foundry

[1] *Iron Age*, Oct. 22, 1914; *Iron Tr. Rev.*, Oct. 15, 1914; *Am. Iron & Steel Inst.*, 1914.

iron was made, and the only trouble was the excessive fluidity of the slag in the latter period. The pig iron was normal in all casts, and carried approximately 0.5 per cent. of titanium, while about 3 to 5 per cent. of TiO_2 was present in the slag.

In the period from June 3 to July 31 the charge was increased successively from 1/8 to 5/16 titaniferous ore, and malleable iron only was made. The pig iron in the several test runs carried silicon varying from 0.70 to 1.70 per cent., and titanium from 0.178 to 0.628; generally, however, the percentage of the latter was about 0.50. Titanium oxide in the slag varied from 2.58 to 10.21 per cent., the higher quantities accompanying the higher titanium content of the charge. Sulphur in the pig iron was low, and there was satisfactory carrying of this element into the slag. Test bars made from the titanium pig showed materially increased strength compared with ordinary iron of the same silicon content.

In general, observations of slag temperatures averaged about 50° F. higher than with non-titaniferous ores. It was observed that the sulphur can be higher in a titanium slag without as much sulphur going into the iron as in ordinary practice.

According to common belief, high fuel consumption usually attends the use of titanium in the furnace, but the results of the tests fail to confirm this supposition. Weekly make of iron, and coke consumption per ton were not materially different for normal ore and titaniferous charges.

The experiments showed that the use of 25 per cent. or more of titanium concentrates in the furnace charge renders it difficult to make a pig iron containing 2 per cent. or more of silicon, since titanium replaces the latter in the iron.

The furnace troubles were unexpectedly few. There were some indications of hanging and slipping in the latter parts of the run, but these were not excessive. No serious scaffolding took place, and the slag was fluid and acidic, contrary to the general belief that the presence of titanium oxide causes a thick and infusible slag.

There has been a steady falling off for several years in the tonnage of titanium-treated steel rails. The maximum tonnage of 256,759 was reached in 1910. It fell in 1914 to 23,321 tons. The change is coincident with the ascendency of the open-hearth process in rail manufacture. Production data are as follows:[1]

[1] *Bull. 2, Am. Iron & Steel Inst.*

	Tons.
1909	35,945
1910	256,759
1911	152,990
1912	141,773
1913	47,655
1914	23,321

With the decline of Bessemer tonnage in rails, the amount of titanium used in their manufacture decreased very markedly. The higher cost of open-hearth rails, together with their assumed better quality, and the uncertainty of the beneficial effect of titanium additions to this character of steel created a hesitancy on the part of the railroads toward incurring the further expense which would accompany the use of titanium. Lately, however, with the knowledge that open-hearth rails presented the same problems of segregation that were present before, interest is being revived in the use of this ferro-alloy. Such data as are obtainable, while not as yet conclusive, indicate a beneficial effect by the addition of titanium, not alone as regards segregation and strength, but also in giving increased wear, in certain instances in the ratio of 2–3.5:1, as compared with the same quality of non-titaniferous rails subjected to the same service conditions.[1]

K. P. Applegate[2] discusses the effect of titanium upon the magnetic properties of iron, in the endeavor to lower the hysteresis loss. Small amounts of pure titanium were beneficial, but larger quantities produced the opposite effect. Commercial titanium alloy additions were not beneficial, and in no case were the titanium steels as good as those with silicon additions.

F. A. J. Fitzgerald[3] claims a very noticeable influence of titanium in keeping the carbon in rail steels more evenly distributed and within prescribed limits.

O. Bensel[4] reports results of investigations of electrolytic methods for the preparation of titanium-copper of high titanium content.

J. Lamont[5] gives the results of experiments upon a series of titanium-iron alloys with titanium content up to 23.40 per cent. Microstructure, freezing-point diagrams, and data of some of the physical properties are noted.

G. F. Comstock[6] finds that the hard spots in titanium-treated rails are due to the formation of titanium nitride. Microscopic examination and comparative tests showed the presence of pink colored inclusions in titanium steels, and never in ordinary kinds. The inclusions were identified as the nitride of titanium.

[1] *Ry. Age Gaz.*, Oct. 23, 1914.
[2] *Bull. Rens. Polytech. Inst.*, 1914.
[3] *Met. Chem. Eng.*, Jan., 1915.
[4] *Metall u. Erz*, I, II, 1914.
[5] *Ferrum*, May, 1914.
[6] *Met. Chem. Eng.*, Sept., 1914.

TUNGSTEN

By Colin G. Fink

The production of tungsten concentrates in the United States in 1914 was the smallest since the year of the panic, 1908. The year's total of 1100 short tons is about two-thirds that of the record year 1910. During the first part of the year the output of ore was practically at a standstill, inasmuch as the steel industry, the chief consumer of tungsten, was contending with an unusually serious depression of business.

After the outbreak of the European war the tungsten industry improved slightly. The principal orders came from foreign countries that were cut off from the German supply of the finished products, tungsten metal and ferro-tungsten. The year closed with every indication that the new year, 1915, would witness another record output of ore and metal. In the following table the weights are given in tons of equivalent of ore carrying 60 per cent. of tungstic acid (WO_3), which is the commercial basis in this country.

PRODUCTION OF TUNGSTEN CONCENTRATE IN THE UNITED STATES (a)
(In tons of 2000 lb.)

Year.	Production.	Value.	Average per Ton.	Year.	Production.	Value.	Average per Ton.
1905	803	$268,676	334	1910	1,821	$832,992	457
1906	928	348,867	376	1911	1,139	407,985	358
1907	1,640	890,048	543	1912	1,330	502,158	377
1908	671	229,955	343	1913	1,537	672,118	438
1909	1,619	614,370	379	1914	1,100	440,000	400

(a) Statistics reported by F. L. Hess, U. S. Geological Survey. Figures for 1914 preliminary.

The price per pound of tungstic acid in the ore increases as the percentage of tungstic acid in the ore increases. The following is a partial schedule of prices prevailing during the first seven months of the year in the Boulder County district. The prices are for material delivered at the mill of the purchasing company. A sampling and assay charge of $3 is made on every lot netting less than $50.

PRICES OF TUNGSTEN ORE IN 1914

Assay, Per Cent. WO_3	Price per Lb., Cents.	Value per Ton.	Assay, per cent. WO_3	Price per Lb. Cents.	Value per Ton.
1	4	$0.80	31	22	$136.40
5	12	12.00	35	23	161.00
10	17	34.00	40	24	192.00
15	20	60.00	45	25	225.00
20	21	84.00	50	27	270.00
25	21	105.00	55	29	319.00
30	22	132.00	60	32½	390.00

In the early part of August a revised schedule was announced by the Wolf Tongue Mining Co., a prominent purchaser of tungsten ores. This schedule showed a cut in prices of about 10 per cent. In the latter part of the year prices were irregular in consequence of the strained conditions brought about by the war.

The price per unit (20 lb. of tungstic acid, WO_3) in 1914 ranged from \$5.85 to \$9 for 60 per cent. ore or concentrates, depending upon the quality and quantity of the ore and the urgency of the buyers' and sellers' needs. The price per unit in 1913 ranged from \$6 to \$7.50. The price for metallic tungsten for use in the steel industry was about \$0.67 per lb. until the outbreak of the war. After the war lots for immediate shipment were sold as high as \$1.35 per lb.[1]

Imports of ore, tungsten metal, and ferro-tungsten were seriously affected by the European war as shown by figures collected by the Bureau of Foreign and Domestic Commerce. In 1914, 267 tons of ore, valued at \$139,697, was imported, against 401 tons, valued at \$213,122, in 1913. The imports of tungsten metal and ferro-tungsten in 1914 amounted to only 192 tons, valued at \$219,506, as compared with 661 tons, valued at \$835,212, in 1913.

United States

Colorado.—The tungsten resources of the United States are probably a good deal larger than have been generally realized. Many new deposits have been discovered in various parts of the Western States. F. L. Hess of the U. S. Geological Survey, considers it very probable that, should prices advance, the country's annual output would soon exceed 2000 tons.

During the greater part of 1914 the mining of tungsten in Boulder County, Colo., was dull. Prices dropped to \$5.85 per unit, which is apparently too low to stimulate activity. The total output of concentrates for Colorado was 630 tons of 60 per cent. WO_3, as against 953 tons in 1913. The shipments from the Boulder field amounted to over five-eighths of the entire United States production.

The chief producers were the Primos Mining and Milling Co. and the Wolf Tongue Mining Co. The Primos mill is located at Lakewood. The company mined 8160 tons of ferberite ore in 1914 and shipped 450 tons of concentrates averaging about 52 per cent. tungstic acid, WO_3; this is equivalent to 390 tons of 60 per cent. concentrates.[2]

The Conger shaft of the Primos Co. is the deepest shaft in the Boulder district. It has reached a perpendicular depth of 700 ft., which on the pitch of the vein amounts to over 800 ft. from surface. In the fifth and

[1] Compare also prices quoted under *England* below.
[2] Figures supplied by C. F. Lake, of Lakewood, Colo.

sixth levels from the shaft the ore deposits were comparatively low grade, but toward the latter part of the year rich ore was uncovered in the lowest level and this is said to be equal to the best ever found in the district.[1] The ore-shoot is continuous in the bottom and its ultimate limit can not be guessed.

The Wolf Tongue Mining Co. mined about 700 tons of ferberite ore in 1914 and shipped 260 tons of 55 per cent. concentrates, equivalent to 238 tons[2] of the 60 per cent. The Wolf Tongue mill is at Nederland.[3]

California.—The most important producer in California is the Atolia Mining Co., with mines in San Bernadino County. The East Union mine is being worked at a depth of more than 600 ft. In 1914 the largest quantity of scheelite produced came from the Atolia district in the Mohave Desert.[4] This district is the largest scheelite producer in the world. The shipments for 1914 were 370 tons of 70 per cent., equivalent to 432 tons of 60 per cent. concentrates.[5] Tungsten ores are met with also in other parts of California, notably near Randsburg and Weldon in Kern County. A little wolframite was mined near Ivanpah in the Clark mountains. The combined output of California and Colorado was more than 95 per cent. of the total for the United States.

Other States.—In *Arizona* new huebnerite deposits were discovered in the Crown King district southeast of Prescott. The mineral occurs in pegmatite. H. R. Wood and associates are working the property in a small way and intend to install a mill. Small quantities of huebnerite were shipped from the Dragoon district; likewise small quantities of wolframite were produced in the Las Guigas Mountains near Arivaca. Edgar T. Wherry of the U. S. National Museum published the following analysis of a sample of ferberite from Cavecreek, Ariz.: 73.74 per cent. WO_3; 17.41 FeO; 4.76 MnO; 0.24 CaO; 1.07 CuO; 2.19 per cent. $(Ta, Cb)_2O_5$. The ferberite is accompanied by a hydrous copper tungstate.

In *Idaho* small shipments of huebnerite ore were made from the Blue Wing district near Patterson Creek in Lemhi County. According to F. L. Hess, the huebnerite is here found in quartz veins occupying fault fissures and carrying besides the huebnerite, lead, zinc, copper, and silver minerals, fluorite, pyrite and muscovite. There are a considerable number of veins ranging from thin stringers to veins 11 or 12 ft. wide. Some of the veins are lean, but lenses in others are very rich. Lead ore, on the Gilmore and Pittsburgh R. R., is the nearest shipping point and is distant about 20 miles in an easterly direction. The Idaho Tungsten Co. has a mill at the mines, Patterson Creek.

[1] *Salt Lake Min. Rev.*, Dec. 30, 1914.
[2] Figures supplied by William Loach, Nederland, Colo.
[3] See MINERAL INDUSTRY, **22**, for description of milling process.
[4] U. S. Geol. Survey.
[5] Figures supplied by the Atolia Mining Co., San Francisco, Cal.

In *Nevada* the United States Tungsten Corporation, at Hub, near Osceola, White Pine County, Nev., shipped 4.5 tons of huebnerite concentrates containing 65 per cent. tungstic acid (WO_3).[1] The ore was milled at the mine.

In *New Mexico* some wolframite was produced near Penasco.

In *South Dakota* wolframite occurs in quartz veins 3 to 4 ft. in width. The quartz is exceedingly hard and glassy and carries some pyrite and tourmaline besides the wolframite.[2] The claims are located between Hill City and Keystone, Pennington County. A 50-ton mill has been erected and several shafts have been sunk. No production was reported for 1914.

In *Utah* a little scheelite was mined in the Deep Creek Mountains.

Tungsten Minerals.—During the course of the year Frank L. Hess of the Geological Survey, published an exhaustive treatise on the Mineral Relations of Ferberite. In the same bulletin appeared a long paper on the Crystallography of Ferberite from Colorado.[3] by Waldemar T. Schaller. We can here quote only a few of the paragraphs and refer the reader to the original accounts.

In Boulder County, throughout the tungsten district, biotite-hornblende granite, in some places gneissoid, granitic gneiss, and quartz mica schist form the country rocks. The gneiss and schist are older than the granite, and all three are of pre-Cambrian age and are cut by later dikes that range in composition from limburgite to granite pegmatite.

On the northwest and southwest sides of the tungsten-bearing area are gold- and silver-bearing veins having the same general trend as the tungsten veins.

In the southwestern part of the field the narrower individual veins are made up almost wholly of ferberite, which has grown from both sides of the crevices and forms combs of small crystals that coalesce at their bases.

In places the ferberite carries considerable manganese and grades into wolframite (*e.g.*, at Ward, Colo.). The only other tungsten mineral so far identified in the field is scheelite (at Crisman).

Associated minerals other than quartz are few and scarce in the ferberite veins of the main part of the field. Spectroscopic examination revealed the following elements in Colorado ferberite: aluminium, calcium, chromium, iron, niobium, copper, magnesium, manganese, scandium, silicon, strontium, titanium, vanadium, and tungsten.

Hess proposes the following definitions for the members of the wolframite series:

[1] Figures supplied by the U. S. Tungsten Corporation.
[2] F. L. Hess, U. S. Geological Survey.
[3] *Bull.* No. 583, U. S. Geol. Surv.

Ferberite.—A monoclinic iron tungstate having when pure the composition $FeWO_4$. It may contain not more than 20 per cent. of the huebnerite molecule $MnWO_4$.

Huebnerite.—A monoclinic magnanese tungstate having when pure the composition $MnWO_4$. It may contain not more than 20 per cent. of the ferberite molecule $FeWO_4$.

Wolframite.—A monoclinic mineral containing the ferberite molecule ($FeWO_4$) and the huebnerite molecule ($MnWO_4$) in all proportions between 20 per cent. $FeWO_4$ and 80 per cent. $MnWO_4$, and 80 per cent. $FeWO_4$ and 20 per cent. $MnWO_4$.

Edgar T. Wherry of the U. S. National Museum[1] recommends the following names: ferro-wolframite, $FeWO_4$; mangano-wolframite, $MnWO_4$; calcio-scheelite, $CaWO_4$; magnesio-scheelite, $MgWO_4$; cupro-scheelite, $CuWO_4$. The names huebnerite and ferberite are to be disregarded altogether. However, the scheme outlined by Hess (see above) appears to be the more practical.

North America

Canada.—The occurrence of tungsten ores in Canada in economic quantities is confined to a few small areas, the most important of which is situated in the central part of Halifax County, N. S., at an altitude of 400 ft. Here the metal is found in the form of scheelite associated with arsenopyrite and contained in the well-known Nova Scotia quartzose slate gold-bearing series. Operations have been under way on these deposits for some 3 or 4 years. The Scheelite Mines, Ltd., has been turning out very satisfactory and high-grade concentrates. Magnetic concentration, after roasting slightly, is employed to get rid of the arsenopyrite. The output for 1914 is estimated at 20 tons. New finds are constantly being made in the Moose River district, which promises to become an important producer.

In Lunenburg County, N. S., scheelite, cassiterite and molybdenite are found together in a quartz porphyry dyke, cutting granite at a point some 3 miles east of New Ross.[2] Some very high-grade huebnerite was found near N. E. Margaree, Inverness County, Cape Breton.

In 1913 a new discovery of scheelite was made in Ontario. Further reports as to the extent of the veins, etc., have not yet been received.

At the Meteor mine in the Slocan district, British Columbia, scheelite was found in lenses up to 3 ft. in length and 3 in. wide, the largest yielding 500 lb. of high-grade mineral. The gold ores of the Kootenay Belle and Queen mines, on or near Sheep Creek, British Columbia, carry an

[1] *Science* **39**, 575. *Proc. U. S. Nat. Museum*, **47**, 501 (1914).
[2] *Min. Jour.*, Jan. 16, 1915.

appreciable amount of tungsten and some of this is recovered with the concentrates from the gold mills. Both wolframite and its alteration product, tungstite, are met with.

In the Cariboo district, near Willow Creek, British Columbia, scheelite and tungstite were found in bunches up to 30 or 40 lb. in weight. This property until recently was some 300 miles from railway communication. Now the line of the Grand Trunk Pacific passes north of Barkerville, and Fort George Station is about 65 to 70 miles from the Willow Creek property.

South America

Argentina.—The ore shipments from Argentina are chiefly wolframite. Exports from Rosario amounted to 539 metric tons in 1913 as compared with 638 tons in 1912. The chief producer has been the mine in the Sierra Córdoba controlled by the Hansa Sociedad de Minas, a German concern. Practically all of the ore was shipped to Germany. A characteristic feature of the Córdoba wolframite is the presence of appreciable quantities of the rare metal niobium, in some specimens running as high as 1.0 to 1.5 per cent. Nb_2O_5.

Bolivia.—Wolframite, scheelite and huebnerite are all found along the eastern cordillera in Bolivia. The whole mountain territory is 1000 miles long and of irregular width. There are about thirty small mines in operation. The total output in 1913 amounted to 564 metric tons of 60 per cent. concentrates valued at $53,500.[1] The preliminary figures for 1914 are 832 tons. According to G. W. Wepfer[2] Aramayo, Franke & Co., own the largest tungsten mines in the districts of Chorolque, Chocaya and Tasna. The ore is wolframite, scheelite, and huebnerite; the production is about 75 tons per month. The major part of the ore is shipped to San Francisco where it nets $400 to $450 per ton.

The ores are found at great altitudes, between 13,500 and 16,500 ft. above sea level. The slopes are too steep for the working and milling of ore, accordingly aerial ropeways are required to bring the ore down to a place where water for concentration is available. The ore is crushed, classified into sand and slimes and concentrated on tables. The middlings are recrushed, classified and further concentrated. Sometimes veins of tungstates and cassiterite are intertwined, in which case the material is crushed, roasted, and concentrated. In treating ore with appreciable silver values the whole material is crushed, the silver is leached out with hyposulphite of lime, as sulphur and lime are found in the country, and the tailings are concentrated.

[1] *Min. Res. of the U. S.*, 1913, Part I, p. 361.
[2] *Eng. Min. Jour.*, 97, p. 125, June 20, 1914.

According to Bolivian mining law, all mineral ground below the surface soil belongs to the state. This ground is not sold outright, but is given out by the government in leasehold. The annual charge is about 72 cts. per acre and as long as this charge is paid in continuity, the miner is in undisputed possession of the property. On the whole, the Bolivian mining laws are good. There are many more undeveloped properties than mines. Many of the mines are very much embarrassed on account of lack of capital. Of late the mining of tin and tungsten has become more profitable than the mining of gold, silver or copper in these districts.

Chile.—Thin veins of wolframite associated with bismuth and other minerals are met with at Agua Colgada in the Carrizal district, not far from Huasco. Although in 1900 the shipments amounted to 125 tons, in recent years the production has dwindled to 20–30 tons.

Peru.—As in the previous year, the three companies in the Conchucos district of the Department of Anchas and Libertad were the only producers.[1] The Peruvian government issued a report giving details of the progress in tungsten mining in the Republic up to the close of the year 1912.[2] The total output in 1912 amounted to 195 metric tons of huebnerite and wolframite, carrying from 64 to 68 per cent. tungstic acid, equivalent to 214.5 metric tons of 60 per cent. concentrates. The Pelagatos mines are being operated at the rate of 100 metric tons of concentrates annually. The capacity of the present mill is from 13 to 14 tons; plans were made to install a 40-ton mill in addition. The Pelagatos ores run about 25 per cent. copper, 25 oz. of silver, and 3 per cent. tungsten trioxide.[3] The principal vein from which the ore is extracted is about 1 meter in width and runs across the Huallapon Mountain, which is one of the peaks of El Plomo range. The Pelagatos ore is crushed and panned by women, the copper ore being discharged into tanks and the tungsten concentrates collected in the pan. The copper ores are subsequently removed from the tanks and again panned and bagged ready for transportation.

The properties controlled by Carl Weiss and Co., of Lima, are situated on Huaura Mountain. The concentrating methods are very primitive but a new mill of 20-ton capacity is about to be installed. The mines are at a very high elevation and the lack of proper transportation facilities is the great obstacle. The mines are situated about 140 miles from the port of Chimbote and over three-quarters of this distance must be covered by mule pack.

The Conchucos Tungsten Co. Ltd., erected a concentrating plant

[1] Mineral Industry, **22**, 765.
[2] Estadistica minera en 1912; C. P. Jiménez, Lima, 1914.
[3] A. H. Hale, *Min. Eng. World*, **302** (1915).

at an altitude of 12,000 ft. The ores of this company carry only tungsten mineral (huebnerite and wolframite). The ore of the Tamboras Mountain consists of tetrahedrite associated with wolframite, similar to the Pelagatos ore. The mines in Santiago de Chuco, in the department La Libertad, produce galena, tetrahedrite, and wolframite-huebnerite. These mines are owned by a Peruvian company. During the course of the year 1914 new deposits of tungsten ore were discovered in the department of Tayabama.

EUROPE

Germany and Austria.—Practically all of the tungsten ore produced in these two countries is from the Zinnwald district in the Erzgebirge, a chain of mountains bordering between Saxony and Bohemia. The mineral is wolframite associated with tin stone. During the last 10 years the annual production of the Zinnwald district has averaged about 110 metric tons (see Table following). In 1912 Austria reported 65.9 metric tons from Teplitz and Elbogen;[1] for the same year Saxony reported 101 metric tons.[2] Germany's home production is insignificant compared with her large import trade; during the last 5 years she had held a monopoly of this trade. In 1912, German net imports of tungsten ore were 4130 metric tons, and in 1913, 4494 tons. The world production in 1912 amounted to 8780 tons and in 1913 to 9575 tons. Germany's export of tungsten metal for high-speed steel was approximately 800 tons annually in 1912 and 1913. Soon after the outbreak of the war the importation of tungsten ore into Germany stopped almost completely; likewise the exportation of metal and ore ceased practically altogether.

Great Britain.—In 1913, 182 metric tons of wolframite, valued at £17,483, were produced, as compared with 193 tons, valued at £16,873 in 1912. The percentage of tungstic acid in the ore is about 60 per cent. Before the war practically the whole supply of tungsten metal came from Germany. When the importation of the metal suddenly ceased a number of steel manufacturers of the Sheffield district promoted a new company, The High Speed Alloys, Ltd., with factory located at Widnes. The object of the company is to import tungsten concentrates directly from Burma and other localities and to reduce these concentrates to metal according to the best modern methods.

Before the war tungsten ore sold in England at an average of 22s. 6d. per unit; the price of tungsten metal in the Sheffield district was 2s. 6d. to 2s. 7d. per lb. delivered at the factory.[3] Toward the close of the the year (1914) the metal sold as high as 5s. per lb.; ferro-tungsten (75–80 per cent.) brought 3s. 9d. per lb.; wolframite varied between 27s.

[1] F. L. Hess, *Min. Res. of the U. S.* for 1913.
[2] *Min. Jour.* 104, p. 129.
[3] J. M. Savage, *Daily Cons. Tr. Rept.*, Dec. 31, 1914.

and 32s. per unit of 20 lb. tungstic acid; and scheelite varied between 31s. and 36s. per unit. In September all further exports of tungsten ore or metal were prohibited.

France.—The ore occurs in the St. Leonard district, Haute Viennes, and in the Limousine district. Upon the 60 per cent. concentrate basis the production in 1912 was 230 metric tons, compared to 170 tons in 1911.

Portugal.—Portugal is the largest tungsten-ore producer in Europe. The annual output is very nearly the same as that of the United States. The latest available figures are those for 1913, when 1380 metric tons of wolframite concentrates was produced. The richest deposits are those in the Sierra de Estrella, in central Portugal. The lodes are very rich, with a maximum width of 10 cm. The ore is mostly of a very complex nature, consisting of closely associated tin stone, wolframite, and arsenical pyrites requiring complicated and expensive separation methods.[1] The production of the ore rests with numerous very small mining concerns. What is most needed in Portugal is a financially strong company which will combine these many small undertakings and introduce modern, efficient methods of mining and concentrating. At present most of the labor of picking, crushing, and concentrating is cheap, local hand work.

The ore from the Borralha mines in the Castello Branco district is free from tin, sulphur, bismuth, and phosphorus. The mineral here is found mostly in quartz veins. The concentrates run 70 to 72 per cent. tungstic acid. Within the last 3 years tungsten mines have been opened out on concessions in the Concello of Sabrosa and Villareal, the total area exceeding 3000 hectares. An analysis of this ore has given the following results: 70.56 per cent. WO_3, 0.32 SnO_2, 3.40 SiO_2, 0.05 Cu, 13.04 FeO, 10.60 per cent. MnO. Water power from the River Pinhao is available for electric power installation.

Spain.—The tungsten-ore production in 1912 amounted to 169 metric tons of 65 per cent. WO_3 concentrates, which is equivalent to 183 tons of the standard 60 per cent. concentrate. In 1913 the production went back slightly, the total being 163 tons 60 per cent. concentrates.[2] Ore is also found in the Marmolejo district of Andalusia. In the past year improved milling and mining methods were introduced.

Asia

Burma.—Burma continues to be the main tungsten-ore producer of the world. The Tavoy district in lower Burma has been the most

[1] W. T. Doerpinghaus, *Metall u. Erz*, **2**, 297, 339.
[2] See Mineral Industry, **22**, 765, for details regarding location of mines, etc.

active during the past year. In the fall of the year shipments were curtailed as a direct consequence of the European war. The production of wolframite in 1913 amounted to 1905 short tons of concentrates containing 60 per cent. of tungsten trioxide; the preliminary figures for 1914 are 1170 tons. The concentrates sell at from $430 to $600 per long ton. The bulk of the shipments has been to Hamburg, the assay made by the German government for duty assessment (2.5 per cent. *ad valorem*) being accepted by buyer and seller.

The geological conditions are granite overlaid by metamorphic schists, sandstones or quartzites.[1] The schists are argillaceous, arenaceous, and graphitic, being the last remnants of former sedimentaries which have in many cases been eroded to the intrusive plutonics. In a number of instances lodes have followed from a schist capping a hill down into the granite without any marked variation being noticeable. The wolframite content did not diminish appreciably, though width of lode was not maintained, a width in schist of 2.5 ft. average narrowing to a bare 2 ft. in granite.

The minerals here associated with wolframite are cassiterite (a regular by-product), galena, pyrite, columbite, molybdenite, tungstite, muscovite, and chlorite.

Prospecting is carried on with great difficulty, owing to the heavy rains from May to November, amounting to about 200 in. in those months. Mining is confined at present to exploiting by adits and is mainly effected by Chinese labor under white supervision. Crushing is by hand hammers and concentrating in cradles. Laborers do their own timbering, but buy candles and explosives. Payment is by result from 20 to 32 cts. per viss (3.5 lb.) when on the lode; from 48 to 96 cts. per ft., according to the ground, for crosscutting. Mining costs per ton of concentrate vary from $145 to $190, crushing, timbering, etc., included; supervision is $25 to $40; transport averages for the district, including bags, $19; office, insurance, freight, etc., $80 to $90; duty, $12; total, $281 to $351. Selling price, $430 to $600, leaving a handsome margin of profit. The town of Tavoy is the only port in the district. The concentrates are sent south to Penang where those containing tin values undergo separator treatment.

Japan.—The production of tungsten ores in Japan in 1913 amounted to 297 metric tons, valued at $117,030, as compared with 205 tons, valued at $70,748 in 1912.[2] Tungsten mines were discovered in the eastern part of Chosen (Korea) and operations commenced. An average of 5 tons per month, valued at $400 per ton, was shipped to Yokahama.[3]

[1] E. M. Lefroy, *Eng. Min. Jour.*, **99**, 684.
[2] H. C. Huggins, *Daily Cons. Tr. Rept.*, Aug. 15, 1914.
[3] R. S. Curtice, *Ibid*, Sept. 21, 1914.

Siam.—The tungsten industry of Siam is of recent development. However, according to a report published in the directory for Bangkok and Siam, wolframite had been known to the Chinese tin miners for a long time as "dead ore." Its commercial value was unknown until recently. In 1911 about 200 short tons (3000 pikuls) of wolframite were obtained from the old tin placers; in 1912, 119 tons and in 1913, 309 tons.[1] The richest deposits of ore were found in Nakon Sri Tamarat on the east coast of the Siamese portion of the Malay Peninsula. Small quantities of ore were mined on the Island of Koh Samui and at Puket on the west coast.

Australia

Queensland.—In 1914, 241 metric tons of wolframite and 194 tons of bismuth-wolframite were produced as compared with 359 tons and 184 tons, respectively, in 1913. No scheelite was reported.[2] This drop in production was not confined to the tungsten industry but was general in the whole mineral industry of Queensland.

There are twelve leases in force beside seven claims. The Ballarat claim is on Rocky Gully and is one of the best producers of Bamford. The upper, now inaccessible, 30-ft. shaft is in greissen having disseminated pyrite with the quartz leaders in the bottom. One of the 50-ton dumps has been roughly retreated and yielded 700 lb. of wolframite. The Davis United, on the eastern fall of Bamford Hill, has been a good producer in its northern part, near the rich ground of the Haymaker and Hit-or-Miss. The ore is wolframite in quartz. This quartz is bluish in tint and vugs are numerous in it.[3]

From the other states of the Commonwealth the reports for 1914 have not yet been received. The production for these is estimated at 300 tons. The output of New South Wales is next in importance to that of Queensland. In South Australia the deposits in the Tankalella field not far from Adelaide are growing in importance.

The World's Output of Tungsten Ores

The following table shows the production of tungsten ores in all of the important tungsten states of the world. Compared with 1913 the total world's tonnage in 1914 showed a decrease of about 30 per cent. due to the exceptionally dull condition of the steel industry.

[1] C. C. Hansen, *Daily Cons. Tr. Rept.*, Oct. 26, 1914.
[2] *Queensland Govt. Min. Jour.*, **15**, p. 574, Nov. 14, 1914.
[3] *Queensland Govt. Min. Jour.*, **15**, p. 574, Nov. 14, 1914.

PRODUCTION OF TUNGSTEN ORES
(Metric Tons; 60 Per cent. WO_3)

Country.	1910.	1911.	1912.	1913.	1914.
North America:					
United States	1655	1035	1210	1397	1000
South America:					
Argentine	751	621	638	539	(a)
Bolivia	210	336	497	564	832
Peru	14	52	214	300	130
Europe:					
England	278	264	193	182	(a)
France	30	171	230	245*	(a)
Germany-Austria	144	126	167	150*	220*
Portugal	1030	980	1330	1380	(a)
Spain	153	96	169	150	84
Asia:					
Burma	370	1020	1905	1732	1064
Siam	.....	182	108	281	(a)
Japan	250	261	205	297	(a)
Australasia:					
Queensland	1040	682	860	543	435
New South Wales	374	465	271	209	....(a) ...
Total world production	6923	6999	8780	9775	7000*

Statistic reported by the U. S. Geological Survey and foreign consuls.
(a) Statistics not available.
* Estimated.

Tungsten can, however, no longer be considered a rare metal. In 1913 the world's metal production in round numbers was as follows:

	Metric tons.		Metric tons.
Copper	1,000,000	Silver	7,800
Zinc	1,000,000	Tungsten	4,800
Lead	1,000,000	Mercury	3,000
Tin	120,000	Gold	680
Aluminium	79,000	Bismuth	500
Chromium	50,000	Cadmium	50
Nickel	32,000	Platinum	9

That is, the tungsten metal output exceeded that of the combined output of mercury, gold, bismuth, and cadmium.

METALLURGY

Publications other than descriptions of newly patented processes have not appeared during the year 1914. Two of the steel works in this country carried out a number of experiments in the electric furnace, but the data are not yet available.

The process of F. M. Becket (U. S. Pat. 1081571) aims to prepare low-phosphorus tungsten metal or ferro-tungsten from certain phosphorus-bearing tungsten ores, which may or may not contain manganese, or from high-manganese, low-phosphorus tungsten ores. Low-phosphorus ores are ground to 100 mesh and mixed with sulphuric acid (sp. gr. 1.84) in the approximate proportion of 200 c.c. acid to 1 kg. of ore.[1] The solution proceeds at ordinary temperatures dissolving from 30 to 90 per cent. of the phosphorus in the course of a few hours; the loss in

[1] For further details see *Eng. Min. Jour.*, 98, p. 16, July 4, 1914.

tungsten is less than 1 per cent. The ore is then washed and dried and is ready for smelting. High-phosphorus ores are first roasted before being subjected to the acid treatment.

An adaptation of the Goldschmidt aluminium reduction process has been made by Voigtlaender (French Pat. 455313). The reaction mixture, $WO_3 + Al$, is brought up to very high temperatures by the application of external heat, so that this heat in conjunction with the heat evolved by the chemical reaction brings the tungsten metal into fusion.

A process for the decomposition of tungsten ores by means of carbon tetrachloride (CCl_4) was patented by Jannasch and Leiste (German Pat. 266973). The ores are heated in a current of CCl_4 vapor and the tungsten chlorides distilling over are decomposed by means of mineral acids. A comparatively pure tungstic acid is obtained.

L. Hills[1] reported results obtained on the magnetic separation of tin-wolfram-bismuth ores. The concentrates contained: 40 per cent. Sn, 22 WO_3, and 6 per cent. Bi. It was possible to remove first a magnetic concentrate; second, a pyrite concentrate; third, a product assaying 70 per cent. WO_3 and 0.7 per cent. Sn; and finally, a residue assaying 56.3 per cent. Sn, 8 Bi and 0.7 per cent. WO_3. With the Ullrich magnetic separator, F. A. Vogel[2] has been able to obtain exceptionally high yields. As a rule he has employed a 2- or 4-pole separator with belt conveyor for feeding the crude ore.

R. J. Wysor has published a series of tests carried out in a 400-kw. Héroult furnace of 4500 lb. capacity. The object of these tests was to recover tungsten from steel scrap.[3] All of the tungsten and about 80 per cent. of the chromium and vanadium content were reduced from a hammer scale containing 58.1 per cent. Fe, 3.1 Cr, 11.2 W, 0.14 S, 26.3 O, 0.2 Mn, 0.01 P, and 0.40 per cent. Si.

Tungsten Alloys

Ferro-tungsten.—As in previous years practically the whole consumption of tungsten has been in the steel industry for the manufacture of high-speed and other special steels. A number of careful investigations of the structure and properties of these steels have been carried out during the year. A detailed account of the manufacture of tungsten steels is given by W. V. Brandt.[4]

The Philadelphia Navy Yard is the purchasing station for the whole U. S. Navy.[5] The Navy Yard (or U. S. government) specifications for tungsten tool steels are: carbon, 0.55 to 0.75 per cent.; chromium, 2.5

[1] *Min. Eng. Rev.*, July 6, 1914.
[2] *Eng. Min. Jour.*, **99**, 287, Feb. 6, 1915.
[3] *Iron Age*, **93**, 910.
[4] *Iron Age*, **86**, 1025 (1914).
[5] High-speed and Carbon Tool Steels, Industrial Press, N. Y., 1914.

to 5.0; manganese, 0.05 to 0.3; phosphorus, 0.15; silicon., 0.3; sulphur, 0.02; tungsten, 16.00 to 20.00; vanadium, 0.35 to 1.50; iron, 72 to 80.5 per cent. The outcome of the Navy Yard specifying the composition and testing the finished product has been most beneficial in furthering the scientific development and progress of the tool-steel industry. High-speed steel has two distinct features of superiority over common steels: (1) It will withstand higher temperatures without softening; (2) it is a better abrasive than carbon tool steel at ordinary temperatures.

Tests made by J. M. Gledhill, in England, show that steel with 9 to 16 per cent. tungsten is very brittle, whereas steel with 18 to 27 per cent. tungsten is tough but not brittle.

When cutting on hard steel there is an actual saving of from 20 to 30 per cent. in power alone, when using the tungsten-steel tool in place of the ordinary carbon-steel tool. In hardening tungsten tools one method is to cover the surface of the tool with fused borax, as a protection, and then to heat the tool quickly to 1260° C.

J. O. Arnold and A. A. Reed investigated the carbides of tungsten in tungsten steels. The specimens tested contained from 0.67 to 0.73 per cent. carbon and from 2.38 to 26.29 per cent. tungsten. The results showed that Fe_3C apparently cannot exist in a steel containing 11.5 per cent. W, which is the minimum limit in modern high-speed steels; all of the carbon is then present as WC. In this respect the effect of tungsten is like that of vanadium, although only 5 per cent. vanadium is required to expel all Fe_3C. Photomicrographs of various tungsten-steel samples clearly showed the presence of three new components: tungsten pearlite, tungsten cementite, and tungsten hardenite.

Tungsten steels are also used for permanent magnets. M. B. Moir[1] investigated the following graded series:

	Carbon.	Tungsten.	Manganese.
A	0.44	2.88	0.24
B	0.43	5.85	0.26
C	0.43	8.72	0.25
D	0.43	11.65	0.26

The steels were all quenched from 900° and the magnetic properties examined. Results show that the residual magnetism diminishes with increasing tungsten content. The coercive force was very nearly the same for all four specimens. If the effect of percussion only need be considered in its application, the first specimen is the best. If the magnet is to be used in apparatus in which it must resist temperature changes only, the third (C) is the most satisfactory. After being submitted to shock and change of temperature, the tungsten steel magnets are much superior in magnetic intensity to even the best chrome steels.

[1] *Electrician* (London) 74, 385 (1914): see also J. A. Mathews, *Proc. Am. Soc. Testing Mat.*; 14, 51 (1914).

Other Tungsten Alloys.—E. Weintraub has patented an alloy of 20 to 60 per cent. tungsten and 80 to 40 per cent. platinum for use in electrical contacts, jewelry, etc.[1]

R. Becker's patent covers an alloy containing, 18 per cent. W., 5 Cr., 4 Co, and 70 per cent. C. Recommended for tools.[2]

Rumschottel tried a number of different methods to get tungsten and copper to alloy but all attempts were unsuccessful.[3]

The addition of about 1 per cent. of tungsten to aluminium has been found to increase its tensile strength. The best results were obtained with tungsten 0.8 to 1.2 per cent., cobalt 8 to 10 per cent. and aluminium the balance.[4]

Properties of Tungsten Metal

H. Arnold gives a very good summary of the chemical and physical properties of the metal tungsten.[5] The fine black powder dissolves readily in a mixture of ammonia and hydrogen peroxide. It is insoluble, however, in all the common acids.[6] A new determination of the melting point of tungsten was made by Langmuir and Mackay; the value found, 3267° C., is about 100° higher than the one last recorded. The vapor pressure of tungsten at temperatures between 2000 and 3100° C. was found to increase with the temperature, attaining the value 0.00114 mm. of mercury at 3100° C.[7] The thermal conductivity and the specific heat of tungsten at very high temperatures was measured by A. G. Worthing and co-workers.[8] At 1227° C. the conductivity was found to be 0.98 watts per cm. per degree centigrade. The specific heat was 0.04 to 0.05 between 1600 and 2200° C.

The physical properties of tungsten metal are summarized in the following table. The values for four other metals are cited in comparison:

	Density at 18° C.	Expans. Coeff. at 18° C.	Tens. Strength, Lb. per Sq. In.	Elastic Mod., Lb., Sq. In.	Spec. Heat Cal., g., 1°C.	Melting Point, Degrees Centigrade.	Elec. Resis. Microhms, Cu. Cm.
Aluminium.....	2.7	21.8 by 10^{-6}	43,000	10 by 10^6	0.214	660	2.62
Copper.....	8.87	15.9	66,000	19	0.091	1083	1.589
Nickel.....	8.75	12.7	96,000	29	0.106	1453	6.93
Iron.....	7.8	11.2	450,000	30	0.105	1600	8.85
Tungsten.....	19.6	3.5	610,000	60	0.034	3267	4.42

NOTE.—The values given for iron in the third and fourth columns are for high tensile strength steel. As for the tungsten values here recorded, the specific heat figure is that of Honda; melting point, that of Langmuir: the others were determined by the writer.

[1] U. S. Patent, 1096 655.
[2] U. S. Patent, 1096669.
[3] *Metal u. Erz*, **12**, 45.
[4] *Ind. Eng.* **14**, 450.
[5] *Zeits. anorg. Chem.*, **88**, 74.
[6] See MINERAL INDUSTRY, **22**, 769.
[7] *Phys. Rev.*, **2**, 329.
[8] *Phys. Rev.*, **4**, 535.

Tungsten Lamps.—A large number of patents have been taken out in 1914 by lamp companies here and abroad, on various steps and refinements in the process of manufacturing tungsten lamps.[1] Wonderful strides were made in the improvement of the gas-filled lamps. The characteristics of gas-filled tungsten lamps are fully described in a paper by Langmuir and Mackay.[2] These are now made in all sizes from 100 to 1500 watts. In many towns and localities the gas-filled lamp has taken the place of the arc lamp. The total production of tungsten lamps, both vacuum and gas filled, in the United States in the year 1914 reached 100,000,000.[3] The exports were 1,348,000 lamps, valued at $278,000.

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————.—Tungsten Steel for Magnetos. *Iron Age*, **95**, 563.

[1] A complete list of these patents will be found in the 1914 index of *Chemical Abstracts*.
[2] *Trans. Illumin. Eng. Soc.* **9**, 775–94 (1914). *Chem. Abstr.*, **9**, 413.
[3] Equivalent to about 3 tons of tungsten concentrates.

URANIUM AND VANADIUM

By Siegfried Fischer

Uranium

In general, no new uses have been found during the year for uranium, in either metal or oxide form. One patent was granted for a new use of uranium, namely, U. S. Pat. 1106384, Aug. 11, 1914, on Uranium as Filament Material. The use of uranium for this purpose has not, however, found commercial application.

United States.—Small deposits of carnotite have been found in Arizona, but are not in operation.

Canada.—Uraconite: found in Hastings and Peterborough Counties, Ontario. The mineral was associated with magnetite in both cases.

Samarskite: found in pegmatite dike on Mica Lake, Berthier County, Quebec.

Pitchblende and ash of carbonaceous material containing as high as 35.43 per cent. uranium in mica near Lake Pieds des Monts, Charlevoix County, Quebec. Pitchblende has also been found at the Villeneuve mica mine, Ottawa County, Quebec.

India.—Pitchblende has been found in the central part of India. It is found in nodular form, frequently surrounded by uranium ocher. The mineral is found in a pegmatite dike on Abraki Pahar, a hill 200 ft. high lying due east of Banekhap, associated with mica, triplite, ilmenite, tourmaline, uranium ocher and, at times, small amounts of columbite zircon, and torbenite.

Salvador.—A uranium deposit was discovered in this Central American state, but the nature of the deposit has not been published.

Sources.—The commercial sources of uranium minerals were the same during 1914 as during 1913, up to August.

Market.—Up to August, 1914, the output of uranium ores was the largest in the history of the country: 4300 tons ore, carrying 87 tons U_3O_8, and 1200 tons ore, carrying 28.1 tons U_3O_8, were consigned to Europe, but owing to the war, some was held in transit. The European war has for the present completely closed the market in Europe for American uranium ores. It has also disorganized the carnotite industry in this country to a large extent.

Prices.—The following schedule for uranium ores was put in effect in Denver:

2 per cent. U_3O_8.....$2.00 per lb. U_3O_8 20–30 per cent. U_3O_8.....$3.25–$3.50 per lb. U_3O_8
3 per cent. U_3O_8.....$3.00 per lb. U_3O_8 50–70 per cent. U_3O_8.....$4.25 per lb. U_3O_8

Technology.—Several concentrating plants for uranium ores have been erected during the year. Both the Standard Chemical Co. and the National Radium Institute have erected plants in southwestern Colorado and are treating low-grade carnotite ores.

Vanadium

The demand for vanadium has been increasing in the steel industry during the year 1914.

Sources.—The sources are the same, patronite, roscoelite and carnotite constituting the main ores. Vanadinite can only be classed as a secondary source.

New Deposits.—A new deposit of vanadium ore was discovered in Baraga County, Mich. The location is 7 miles north of Skanee and some 30 miles from L'Anse, the nearest railway station. The ore is endlichite, a lead vanadate. The ore-body is a fissure vein and at a depth of 12–13 ft. is 24 in. in width and seemingly increases as the depth of the shaft increases. The trend of the vein is N. E.–S. W., and the dip is almost vertical. The ore body itself is a soluble silicate, showing besides vanadium a small percentage of uranium, a calcium carbonate or a magnesium carbonate graduating toward dolomite. The iron content of the ore varies but is always present. The foot wall is slate and the hanging wall serpentine. The country rock is altered serpentine. As depth is obtained, there are strong indications of uranium, especially on the foot wall. The uranium is in the form of a yellowish-green coating. Analysis of the ore showed vanadium, 21.5 per cent.; uranium, traces.

In another mine, the Mohatin mine, vanadium ore is found in form of high-grade carnotite. The carnotite is interspersed through the seams, fissures and crevices of the country rock. As the development of the property is not sufficiently advanced to give concise ideas about the amount of material at hand, the tonnage of the ore can not be given, but present outlook promises a large deposit of vanadium ore.

New Vanadium Minerals.—Hewettite, metahewettite, and pascoite, hydrous calcium vanadates.

Hewettite.—$CaO.3V_2O_5.9H_2O$. Mahogany red in color with silky to earthy luster. Sp. gr. 2.554 and when air dried, 2.618. Probably orthorhombic in needles. It is found in Peruvian ores and is most likely an oxidation product of patronite with partial replacement of the vanadium by calcium.

Metahewettite.—Isomeric with hewettite. Bright red in color with earthy luster. Sp. gr. 2.511 and when partially dehydrated, 2.942.

Orthorhombic in minute tablets. Found in Paradox Valley, Colo., at Thompson's and Henry Mountains, Utah, in sandstone usually admixed with other minerals.

Pascoite.—Named after Pasco County, Peru, where it is found. $Ca_2VO.11H_2O$. It represents complete neutralization of the vanadium by calcium. The mineral is red-orange in color and subadamantine in luster. Probably monoclinic in thin plates.

All three minerals are more or less soluble in water, the pascoite dissolving very readily, the others less.

Market.—The market demand for vanadium has steadily increased during the year. Most of the vanadium still comes from Peru and is handled by the American Vanadium Co. While there are no statistics at hand, it is fair to assume an increased output over 1913. As there is no special payment for the vanadium in carnotite ores, no figures are given for the metal produced from this ore. Again, regarding the figures for the output of uranium ores, we may justly assume that the vanadium from this source has also increased.

Technology.—Several advances and improvements have been made in the metallurgy and in the application of vanadium.

It was long considered an impossibility to produce ferro-vanadium alloys directly from iron ores containing vanadium, due to the fact that the vanadium slags very readily. Baxeres de Alzugaray claims to have found a means of preparing said alloys directly from the ore, but he gives no information regarding his process.

Experimental investigations have been made by E. O. Fitch regarding the influence of vanadium on pig iron, and he found that it improved the soundness, uniformity, fine grainedness and workability of the pig iron. Special steels are used by the Cleveland-Canton Spring Co. The Union Steel Casting Co. developed a vanadium cast steel for die blocks and heavy drop forge work. This steel has a carbon content of 0.45–0.50 per cent. Steels for resisting fatigue are made to contain 0.25 per cent. carbon and not under 0.15 per cent. vanadium. This type of steel, it is claimed, will resist shock and therefore the crystallization caused by it.

In general we may say that vanadium is penetrating more and more into the machine industry. The demand for vanadium steel castings for locomotives, automobiles and other vehicles is steadily on the increase, and smaller castings, lathes, and other machine parts requiring increased tensile strength are a vast field for the application of vanadium.

ZINC

By R. L. Bartlett

Owing to the fact that the greatest zinc-smelting centers of the world, outside of United States, are located in the war zone of Europe, the effect of the war on the spelter market has been most pronounced. The European smelters have either been forced to suspend operations or, if able to operate, their product has not been able to reach the outside world. Owing to the war, also, it has been impossible to secure figures of production for many foreign countries. Mr. C. F. Siebenthal, of the U. S. Geological Survey, has reviewed the effect of the war on the zinc industry, as follows:

"The unprecedented and spectacular rise in the price of spelter in January and February of 1915 has caused the statistical position of spelter to be examined as never before. The large stocks at smelters at the beginning of 1914, the much larger stocks at smelters at the midyear, and the great demands for zinc for export for war purposes have served to augment the deep interest in this metal.

"The production of primary spelter made a substantial gain in 1914, and this, taken in conjunction with the large stocks, made available a far greater supply of primary spelter than ever before. Although the production of secondary spelter fell off markedly, nevertheless the total spelter available for consumption was the greatest in the history of the industry. Only the enormous exports of spelter for use in the war prevented a great increase in stocks. As it was, stocks were greatly reduced from the quantities in hand at the first of the year and the midyear, and at the close of the year were only moderately large. The apparent consumption of primary spelter was slightly larger than in 1913, and seems a reasonable figure.

"The relatively small stocks at the close of 1914, in the face of the very large quantity of spelter available for consumption, might suggest that there were large "concealed" stocks of spelter in the hands of consumers and brokers. In 1912 the quantity of spelter available for consumption was very great, yet at the close of the year there were smaller stocks than for many years. Later events showed that on the strength of the rising market during the year large stocks had been laid in by consumers and others, which are not taken into account in the statistics. In 1913 there was again a large quantity available for consumption, but owing to declin-

ing prices of spelter the concealed stocks in consumers' hands satisfied the demands of the market, and at the smelters the large stocks accumulated which are shown in the statistics for that year. It will be observed, however, that large concealed stocks must necessarily be accompanied by an abnormally large apparent consumption. The apparent consumption for 1914, as shown by the figures above, is not abnormally large.

"However, if it could be shown that the spelter-consuming industries were at a low ebb and probably absorbed only a small fraction of their normal consumption, then it would appear probable that the apparent consumption given above, though not over-large, might represent a considerable quantity which had been withdrawn from the market for speculative purposes. It has been claimed that the brass industry ran on a 60 per cent. basis during the latter part of 1914, and at the same time the iron and steel industry (including galvanized products) was on a 50 per cent. basis. These figures seem too pessimistic. Responses from a limited number of representative and important interests indicate that the consumption of spelter in galvanizing in 1914 was about 90 per cent. what it was in 1913, and that the consumption of spelter in brass making was about 88 per cent. that of 1913. These two industries probably account for about 80 per cent. of the spelter consumption of the United States. If the considerable decrease in the quantity of secondary spelter recovered in 1914 be borne in mind, it does not seem probable that there can be any large quantity of concealed spelter stocks in existence. A consideration of the total apparent consumption of spelter for a period of years leads to the same conclusion.

TOTAL CONSUMPTION OF SPELTER, 1908–1914

	Apparent Consumption of Primary Spelter.	Production of Secondary Spelter.	Approximate Total Spelter Consumption.	Estimated Normal Total Consumption of Spelter.
1909	270,730	33,040	303,770	285,000
1910	245,884	41,223	287,107	304,000
1911	280,059	40,513	320,572	322,500
1912	340,341	52,251	392,592	341,000
1913	295,370	50,015	345,385	360,000
1914	299,130	42,615	341,745	378,500
Total	.....	.....	1,991,171	1,990,000
Average	.....	.....	331,862	331,666

"To estimate the total apparent consumption of spelter in the United States, the production of secondary spelter, both re-distilled and re-melted, should be taken into account. The stocks of secondary spelter are not available, so that consumption of secondary spelter must be assumed to be the same as the production, which must be very nearly the fact, for the reason that secondary smelting interests are generally small. The annual

figures of apparent consumption of primary spelter and of the production of secondary spelter are given above. The figures for 1907 and 1908 are not used, because the figures of production of secondary spelter for those years are possibly not complete. If used they would apparently result in a somewhat lower average consumption and indicate a somewhat larger annual increase.

"From the figures of approximate total consumption for 1909–1914 given above we may make an estimate of the normal consumption of spelter for those years and the annual normal increase. The average yearly approximate consumption for the period is 331,813 tons. The consumption for 1912–1914 is about 84,000 tons in excess of the average for the whole period, and the consumption for 1909–1911 is about 84,000 tons less than the average. From these facts we may readily determine the normal annual increase and can then estimate the normal consumption of spelter, both primary and secondary, as given in the last column of the table above. The normal or prospective consumption of spelter for 1914 is seen to be 37,000 tons greater than the indicated actual consumption, from which it is to be inferred that large concealed stocks of spelter at the close of 1914 are not probable.

"If spelter-consuming industries in the United States enjoy prosperous conditions in 1915, so that the total spelter consumption makes its normal gain (which, however, in view of the high price of spelter and the resulting effect on domestic consumption is scarcely probable), figured on the totals for the last 6 years, as shown in the last column of the table above, the total domestic spelter consumption for 1915 would approximate 397,000 tons. If to this we add a year's domestic exports at the rate shown since the beginning of the war in Europe, 180,000 tons, and a year's foreign exports at the rate during the latter half of 1914, equal to 17,000 tons, we get 594,000 tons as the possible demand for spelter. This, however, is not the maximum possible quantity to be demanded. Attention was directed by the United States Geological Survey in a press bulletin, in August, 1914, to the opportunity for the American zinc industry to supply the major part of 222,000 tons of export spelter a year as long as the war lasts. As pointed out above, exports of spelter for 7 months have been made at the rate of 197,000 tons yearly. Moreover, there remains the possibility of the trade in galvanized sheets, wire, and products with the southern continents and Asia. So far this has not been touched. The exports of galvanized sheets in 1914 were 45,318 short tons, compared with 86,475 tons in 1913. The exports of barbed wire, plain and galvanized, were 105,078 tons, as compared with 107,586 tons in 1912. When the United States comes into its share of the trade in galvanized products with the southern continents and Asia, the domestic consump-

on of spelter will be increased and will in turn increase the total possible emand for zinc given as 594,000 tons above.

"On consideration, the domestic smelting capacity seems scarcely more ıan equal to this possible demand. The total number of ordinary retorts ɔmpleted and contemplated at the close of 1914 is 124,016. Some of ıose contemplated can not be completed before the latter part of the resent year. If we estimate the average capacity per retort as 4¼ ɔns of spelter per year, the capacity of 124,016 ordinary retorts together ith the large retorts listed is approximately 535,000 tons. Add to this),000 tons of stocks on hand and 30,000 tons of re-melted spelter, we get 35,000 tons. If we take into account that the maximum smelter ca- acity indicated above can not be reached until the latter part of the ear, and consider the possibility of increased demand for galvanized roducts, it seems very improbable that there will be any surplus smelter apacity or accumulation of spelter stocks during the year. Apparently continued decline in prices can come about only by a slackening in ıe foreign demand for spelter for war purposes.

"It remains to consider whether the zinc resources of the United tates together with the contiguous countries usually drawn upon will be qual to the possible demands of the immediate future. The total ecoverable zinc available for spelter and the production of primary spel- er for 1907–1914 are given in the following table:

ZINC AVAILABLE FOR SPELTER IN THE UNITED STATES, 1907–1914, IN SHORT TONS

	Recoverable Zinc Content of Domestic Ore.	Recovered Zinc Content of Imported Ore.	Total Recoverable Zinc Content of Ore Available in United States.	Zinc Content of Pigments Made from Ore.	Total Recoverable Zinc Available for Spelter.	Primary Spelter Production.
907	259,951	29,544[1]	289,495	56,931	232,564	249,860
908	234,526	20,399	254,925	48,004	206,921	210,424
909	305,423	26,715	332,138	54,139	277,999	255,760
910	327,712	19,492	347,204	50,660	296,544	269,184
911	345,260	17,619	362,879	46,376	316,503	286,526
912	378,816	16,498	395,314	62,876	332,438	338,806
913	418,832	9,433	427,815	67,699	360,116	346,676
914	.....	9,729	.....	69,871	.....	.....
Total					2,023,085	1,957,236
Apparent unused surplus					65,849	.....

[1] Does not include all the zinc recovered from imported ore in the form of pigments.

"The average yearly increase in recoverable zinc content of domestic ɔre for the period 1907–1913, inclusive, is 26,405 tons. No figures are ıvailable for the zinc content of ores mined in 1914. Adding the average ɣearly increase for 2 years to the output of 1913 we get 471,192 tons as a ıormal estimate of the output of domestic mines for 1915. Adding 10,000 ɔns as probable imports in ore and subtracting 70,000 tons as probable

zinc content of pigments we get 411,000 tons as the probable zinc in ore available for spelter in 1915. To this should be added the 20,000 tons of spelter stocks on hand at the beginning of 1915, making 433,000 tons available. This is to be set off against a possible demand for 594,000 tons, as pointed out above. It will be observed from the table above that the total recoverable zinc available for spelter for 1907–1913 was about 66,000 tons in excess of the actual production of spelter for the same period. This is to be accounted for as increased ore stocks at the large new smelters, oxide plants, and separation plants which have been built since 1907, and is in large part available for immediate consumption. Adding this to the 433,000 tons, we should have roughly 500,000 tons supply available for treatment in 1915. To this there is to be further added the production of secondary spelter, which reached 52,251 tons in 1912 and could no doubt be expanded to 60,000 tons or more if the occasion arises. So that if the United States is called upon in 1915 for the possible supply of 594,000 or even 600,000 tons of spelter, the zinc will be probably at hand without increasing the mine production above the normal, to furnish nearly 560,000 tons of it. The remainder would easily be supplied by increased production from Montana, Idaho, Colorado, New Jersey, Tennessee, and other states, under the stimulus of high prices. In the Joplin district alone much lean sheet-ground territory not recently operated would become productive under continued high prices, to say nothing of increased production from operating and new mines.

"Zinc ore was imported from Mexico at the rate of less than 200 tons of zinc content per month for the first 8 months of 1914. Conditions limiting the shipment of zinc ore from that country have recently eased up somewhat and the imports for the period September, 1914, to February, 1915, inclusive, have averaged 1600 tons of zinc content, so that a larger supply than for the last 2 years is to be expected from that country. The available supply from Canada will no doubt be largely increased by the high prices.

"In conclusion, it appears that spelter is in a highly advantageous position as far as the statistics afford evidence, and the only danger to be apprehended is that the prevalence of high prices may so limit the domestic consumption as to partly offset advantage gained from the increased foreign demand. The high price of galvanized sheets, for instance, has led some rolling mill operators to advise their customers to substitute heavier black sheets coated with paint. It further appears that the zinc resources of the United States are amply able to satisfy any possible demand that is likely to be made upon them in the immediate future, without drawing upon the zinc tailing piles of Australia."

Spelter Statistics for 1914[1]

Revised and complete statistics of the zinc industry in 1914 are given, reports having been received from all of the ore smelters. Reports from the dross and scrap smelters are only partially complete, however, and

PRODUCTION OF SPELTER
(In tons of 2000 lb.)

States.	1910.	1911.	1912.	1913.	1914.
By Ore Smelters					
Colorado	6,564	7,477	8,860	8,637	8,152
Illinois	79,570	88,681	94,902	111,551	130,587
Missouri-Kansas	112,182	106,173	111,761	85,157	53,424
Oklahoma	34,760	46,333	76,837	83,230	92,467
East	43,989	47,172	56,278	69,687	77,731
Totals	277,065	295,836	348,638	358,262	362,361
By Dross and Scrap Smelters					
	11,350	(a) 13,500	(a) 15,000	(a) 20,500	(a) 18,000
Total Production of Spelter					
Ore smelters	277,065	295,836	348,638	358,262	362,361
Dross smelters (a)	11,350	13,500	15,000	20,500	18,000
Totals	288,415	309,336	363,638	378,762	380,361

(a) Estimated. It is difficult to obtain reports from all of these smelters. The large increase in production from 1912 to 1913, as here reported, was due in part to a more complete statistical accounting.

SPELTER PRODUCTION IN 1913 AND 1914 BY QUARTERS
(Reports of Ore Smelters Only)
(In tons of 2000 lb).

District.	I.	II.	III.	IV.
1913				
Illinois	27,924	28,523	26,118	28,986
Kansas-Missouri	22,006	23,820	19,204	20,127
Oklahoma	21,430	21,840	18,502	21,458
Others (a)	20,722	20,153	19,238	18,211
Totals	92,082	94,336	83,062	88,782
1914				
Illinois	31,005	32,482	32,512	34,588
Kansas-Missouri	13,939	14,659	13,193	11,633
Oklahoma	22,563	22,960	22,945	23,999
Others (a)	20,700	20,703	21,819	22,661
Totals	88,207	90,804	90,469	92,881

(a) With the exception of one plant in Colorado these are all Eastern works.

the production of their class of spelter is estimated on the basis of partial returns, but reports were missing from a few of the smaller concerns only. Certain smelters who treat both ore and dross are included with the ore smelters.

[1] W. R. Ingalls, *Eng. Min. Jour.*

Production.—The total production of spelter by ore smelters in 1914 was 362,361 tons, of which 8380 tons was derived from galvanizers' dross, skimmings, scrap, etc., and the remainder from ore. The production from dross, skimmings, scrap, etc., was 8764 tons in 1913; 7447 in 1912; 9030 in 1911; and 7793 in 1910. These data do not include the production by concerns which treat dross and scrap only, whose output amounts to about 20,000 tons per annum.

Ore Smelted.—The smelters who treated ore reported that in 1914 they smelted 628,886 tons of blende and 226,549 tons of calamine. It should not be attempted to draw too fine deductions from these figures respecting the average yield of the ore smelted, some smelters having apparently reported "ore received" as "ore smelted." In those cases where a discrimination was made the figures showed differences between the quantities of "ore received" and "ore smelted," reflecting increases and decreases in the ore stocks at smelting works. The total report of "ore smelted" was 855,435 tons and of "ore received," 872,767 tons. This was partly due to the stocking of the new works at Langeloth and Tiltonville, but even without that there was a surplus of ore receipts, which was the more noteworthy in view of the suspension of Butte & Superior shipments for 2 months.

The ore statistics show accurately, however, the relative proportion of blende and calamine smelted. With the exception of the Palmerton plant of the New Jersey Zinc Co., which smelts chiefly the willemite concentrate of Franklin Furnace, N. J., the bulk of the calamine ore was smelted by works in the gas fields of Kansas and Oklahoma. One large

RECEIPTS OF ZINC ORE

(In tons of 2000 lb. This table includes the receipts of ore by the smelters only and does not include the production of ore exported or what was taken by the manufacturers of zinc oxide)

State.	1910.(a)	1911.(a)	1912.(a)	1913.	1914.
Arizona	7,568	6,395	11,937	9,347	6,357
Arkansas	190	860	1,567	1,500	1,737
California	(d)	3,754	6,639	6,796	8,827
Colorado	77,065	158,528	212,423	220,166	164,739
Idaho	10,248	9,667	19,482	31,835	57,001
Kentucky	179	575	947	441	434
Missouri-Kansas	289,913	268,500	289,177	280,000	247,723
Montana	33,514	56,593	34,034	91,257	125,663
Nevada	4,915	5,666	20,654	22,313	20,447
New Mexico	15,959	10,184	25,889	14,593	15,369
Oklahoma	1,640	8,750	4,325	23,500	26,247
Tennessee	2,775	3,439	6,635	8,297	18,708
Utah	27,318	19,933	24,539	27,073	20,322
Wisconsin (b)	51,383	71,565	90,762	89,662	74,311
Others	46,905	44,896	56,099	57,241	57,936
Totals	569,572	669,305	805,109	884,021	845,821
Mexico	29,198	28,596	29,436	19,965	16,414
Canada	11,795	2,356	9,707	6,012	10,532
Grand totals (c)	610,565	700,257	844,252	(c) 909,998	872,767

(a) Smelters' receipts; reports missing from three small smelters. (b) Including Illinois and Iowa. (c) In addition to the ore reported from Canada and Mexico, zinc smelters received a few thousand tons from Europe and Eastern Siberia in 1913. (d) Included in "Others."

plant was operated exclusively with calamine. The smelters east of the Mississippi River make sulphuric acid, with the exception of two small concerns, and naturally use blende, but some of them take relatively trifling quantities of calamine.

With the movement of the zinc-smelting industry to the eastward, the separation of blende roasting and zinc distillation is becoming more marked, as it has been for a long time in Europe. It is often good business to roast the blende at a good center for the distribution of sulphuric acid and re-ship the roasted ore to a good point for zinc distillation. The Western Chemical Co. has for a long time roasted ores at Denver, Colo., and sold the roasted ore to other smelters. The National Zinc Co. has no roasting furnaces at its smeltery at Springfield, Ill., which gets its ore from the roasting plant of the company at Argentine, Kan. Similarly the Grasselli Chemical Co. roasts at Canton, Cincinnati, Newcastle, Cleveland, and Grasselli the ore that is needed by its smelteries at Clarksburg and Meadowbrook. The New Jersey Zinc Co. has a roasting plant at Tiltonville, Ohio, which supplies other smelters.

The table showing ore receipts gives the totals of ore reported as taken in by the smelters. This is not equivalent to the ore production of the several states, inasmuch as ore that went to the zinc-oxide plants at Coffeyville, Kan., Mineral Point, Wis., and Palmerton, Penna., is not included. For this reason the ore received by the smelters of spelter was considerably less than the outputs of Colorado, New Mexico, Wisconsin, and New Jersey (included in "other states"). With those exceptions, however, the figures in the table probably correspond closely with the productions of the several states.

The ore statistics have some noteworthy features. Several states exhibit important increases in 1914, notwithstanding the low average price for spelter (5.06 cts., St. Louis, compared with 5.50 cts. in 1913 and 6.80 cts. in 1912). In Montana the Butte and Superior Co. made an increased output, although it suspended production from Oct. 18 to Dec. 19. Timber Butte, a new and important producer, began operations June 1. In the Cœur d'Alene district of Idaho the Interstate-Callahan mine became a large producer. The increased output of Tennessee was due especially to the mine of the American Zinc, Lead & Smelting Co. in the Holston River district. The Yellow Pine district of Nevada, which produces calamine ore, fell off a little in output.

Leadville, the chief zinc-producing district of Colorado, made about the same production in 1914 as in 1913. The Leadville *Herald-Democrat* gives these figures: 52,689 tons of blende and 157,286 tons of calamine in 1913; 204,427 tons of blende and calamine in 1914. These figures show only a slight decrease from 1913 to 1914, which does not agree with

the Colorado ore receipts reported by the smelters. The latter show a large decrease.

The zinc-ore production of the Joplin district declined on account of the low range of prices, at which many of the "sheet-ground" mines could no longer be worked profitably and were therefore abandoned. Considering the conditions, it is perhaps surprising that the Joplin production did not show a larger decrease.

The outputs of both Wisconsin and Oklahoma increased, according to local statisticians, but smelters' receipts showed a decrease in Wisconsin and only a slight increase in Oklahoma. It is possible that the discrepancy in the case of Wisconsin would be explained by returns from the oxide works. In the case of Oklahoma, some of the ore originating there was doubtless reported by the smelters as coming from the Joplin district and was entered with the figures from Missouri and Kansas. In Wisconsin 46 mills and five magnetic-separating plants were in operation at various times during the year. In Oklahoma the only active mining district was Miami. Improvements in the methods of ore concentration there led to the production of blende concentrate assaying 60 per cent. Zn and as low as 2 per cent. Fe.

In New Mexico the Magdalena district was the chief producer of zinc ore, and in Utah the major part came from the mines at Park City.

The production of floated blende concentrate in 1914 was nearly 100,000 tons. In this connection let it be noted that the mills employing the flotation process produce a large proportion of jig and table concentrate as well as the floated froth. The production of floated concentrate is without doubt destined to increase materially during the next year or two.

Bonded Spelter.—In 1914 there was produced 5630 tons of spelter in bond. In 1913 the production in this way was 5904 tons; in 1912 it was 10,879 tons; in 1911 it was 9598 tons; and in 1910 it was 3398 tons. The exports of bonded spelter are stated in an accompanying table.

Spelter Production According to Fuel.—Of the total spelter production of the ore smelters in 1911, concerns using coal as fuel produced 119,989 tons, or about 40 per cent. of the total. In 1912 they produced 134,077 tons, which was only about 38 per cent. of the total. In 1913 their production was 157,653 tons, or about 44 per cent. of the total, and in 1914 it was 173,520 tons, or about 48 per cent. of the total. The remainder of the production was made by smelters using natural gas as fuel, with the exception that one employs a little crude petroleum along with natural gas.

Dross and Scrap.—The amount of the recovered spelter that should properly be counted statistically is uncertain. A good deal of scrap zinc is re-melted in the manufacturing plant where it is made, *e.g.*, in every rolling mill, and such re-melted zinc should not, of course, appear in any

statistical enumeration. On the other hand, certain smelters buy and re-distil and subsequently sell as spelter, often of excellent quality, what was distinctly a waste product. This is obviously an addition to the new supply of spelter and should be recognized just as is that which the ore smelters recover from dross, skimmings, etc. In my estimate I have conformed to this reasoning.

A point that deserves note is the increasing production of spelter from dross and the decreasing exports of that material. In 1911 the exportation was 2446 tons; in 1912 it was 205 tons; and in 1913 it was only 28 tons. But in 1914 the exportation of dross jumped to 2525 tons, domestic production of dross-spelter being correspondingly less. I estimate the product re-distilled from dross, skimmings, etc. (by works treating this material only), at 13,500 tons in 1911, 15,000 tons in 1912, 20,500 tons in 1913, and 18,000 tons in 1914, and probably these figures are under-estimates rather than over-estimates. In taking a statistical view, this spelter must be added to the spelter obtained otherwise, it being sold in the same way.

Adding to the reports of the dross smelters the metal made by ore smelters out of dross, skimmings, etc., there was a total recovery of 26,230 tons of secondary spelter in 1914, compared with 29,264 tons in 1913.

Zinc Dust.—The production of commercial zinc dust in 1914 was 1042 tons, compared with 423 in 1913, 492 in 1912, and 254 in 1911. In 1913 only two smelters were engaged in this manufacture; but when the outbreak of the war in 1914 cut off America's foreign supply and the price rose from about 6 cts. per lb. to 15 @ 16 cts., several additional smelters engaged in the manufacture of it. The importation of zinc dust was 2302 tons in 1914, compared with 2200 in 1913, 2400 in 1912, and 1713 in 1911.

Spelter Stocks.—Fifteen smelting companies reported by telegraph stocks on Dec. 31 aggregating 19,500 tons. Six companies reported works idle. Three companies, one very small, failed to report their stocks. Estimating 4000 tons for them, the total stock in the hands of smelters on Dec. 31 was 23,500 tons. The stocks at the ends of previous years are reported in an accompanying table. According to the government statistics, the stock at the middle of 1914 was 64,000 tons.

Sulphuric Acid.—In 1914 there were nine smelters who produced sulphuric acid from blende, the American Zinc & Chemical Co. being an addition to the list. The statistics of the works of this class for a series of years are given in an accompanying table. It is to be remarked that although the American Zinc & Chemical Co. produced acid in 1914 it did not produce spelter, its distillation furnaces not being completed and its roasted ore being stocked. As in previous years, the smelters who made sulphuric acid drew their main ore supply from the Joplin district, and

from Wisconsin, Oklahoma, and Tennessee, whereof the ore supply is mainly a high-grade and relatively pure blende. In 1911 these smelters received 107,995 tons of blende from the Joplin district and 71,168 from Wisconsin; in 1912 they received 117,806 and 87,676, respectively; in 1913 they received 159,540 and 84,495, respectively; and in 1914 they received 179,237 and 74,311, respectively. Oklahoma and Kansas are reckoned with the Joplin district and Illinois and Iowa with Wisconsin.

STATISTICS OF SPELTER-SULPHURIC ACID WORKS
(In tons of 2000 lb.)

	1910.	1911.	1912.	1913.	1914.
Ore received	.....	.....	287,205	364,741	434,666
Spelter produced	100,791	115,310	127,655	148,188	196,539
Sulphuric acid, basis 60°	202,000	252,192	262,555	305,167	355,424

These statistics indicate the predominance of the sulphuric acid makers in the markets for the pure, high-grade ores. They take all the blende of Wisconsin and Tennessee, which they command geographically, and the major part of the production of the Joplin district, out of which their competition has practically forced the Kansas and Oklahoma smelters, of whom the Edgar Zinc Co. is the only large buyer of the best sorts of Joplin ore.

It is noteworthy that some of the Eastern smelters are using increasing supplies of Rocky Mountain ores.

Smelting Capacity.—The capacity of the zinc-smelting works of the United States at the end of 1914 is given in an accompanying table. Among the active plants, Sand Springs was new in 1914, having begun production in the third quarter. The list is classified according to (1) active plants; (2) plants that are maintained in working order but which are of uncertain future; (3) inactive plants; and (4) new plants building.

At the end of 1914 returns from nearly all of the plants of class 1 indicated that about five-sixths of this capacity was then in use. All of the plants of classes 2 and 3 were idle and had been so during most of 1914. Of the two plants in class 4 that at Langeloth had just put its first furnace in operation, while the new Granby plant was understood to be nearly ready to run.

Among the plants of class 1 the Matthiessen & Hegeler Zinc Co. was the only one having new capacity in preparation, with a new furnace of 912 retorts building. Among the plants of class 4, the American Zinc & Chemical Co. had 1728 retorts building.

In 1914 about 362,000 tons of spelter was produced in 22 works using about 83 per cent. of their capacity. Old works, if operated at full capacity, were consequently able to produce about 56,000 tons more of

ZINC-SMELTING CAPACITY OF THE UNITED STATES
(Number of Retorts at End of Years)

Name.	Situation.	1913.	1914.
Active.			
American Zinc Co., of Illinois	Hillsboro, Ill.	3,200	4,000
Bartlesville Zinc Co.	Bartlesville, Okla.	5,184	5,184
Bartlesville Zinc Co.	Collinsville, Okla.	8,064	8,064
Clarksburg Zinc Co.	Clarksburg, W. Va.	2,712	1,824
Edgar Zinc Co.	St. Louis, Mo.	2,000	1,100
Edgar Zinc Co.	Cherryvale, Kan.	4,800	4,800
Granby Mining & Sm. Co.	Neodesha, Kan.	3,760	3,840
Grasselli Chemical Co.	Clarksburg, W. Va.	5,760	5,760
Grasselli Chemical Co.	Meadowbrook, W. Va.	6,912	6,912
Hegeler Zinc Co.	Danville, Ill.	1,800	(*d*)1,800
Illinois Zinc Co.	Peru, Ill.	4,640	4,640
Robert Lanyon Zinc & Acid Co.	Hillsboro, Ill.	1,600	1,840
Lanyon-Starr Sm. Co.	Bartlesville, Okla.	3,456	3,456
Matthiessen & Hegeler Zinc Co.	La Salle, Ill.	5,256	5,256
Mineral Point Zinc Co.	Depue, Ill.	6,800	9,080
National Zinc Co.	Bartlesville, Okla.	4,480	4,260
National Zinc Co.	Springfield, Ill.	3,200	3,200
New Jersey Zinc Co.	Palmerton, Penn.	5,760	5,760
Prime Western Spelter Co.	Gas City, Kan.	4,768	4,768
Sandoval Zinc Co.	Sandoval, Ill.	896	896
Tulsa Fuel & Manufacturing Co.	Collinsville, Okla.	6,232	6,232
Tulsa Spelter Co.	Sand Springs, Okla.	.....	4,000
United States Zinc Co.	Pueblo, Colo.	1,920	1,920
Totals		93,200	98,592
Operated Irregularly.			
Altoona Zinc Smelting Co.	Altoona, Kan.	3,300	(*b*)3,840
American Zinc, Lead & Sm. Co.	Dearing, Kan.	3,840	(*a*)3,840
American Zinc, Lead & Sm. Co.	Caney, Kan.	3,648	(*b*)3,648
Chanute Zinc Co.	Chanute, Kan.	(*b*)1,280	(*a*)1,280
La Harpe Spelter Co.(*c*)	La Harpe, Kan.	1,856	(*b*)1,856
Totals		13,924	14,464
Inactive.			
Collinsville Zinc Co.	Collinsville, Ill.	(*b*)1,536	(*a*)1,536
Pittsburgh Zinc Co.	Pittsburgh, Kan.	(*b*) 910	(*a*) 910
Totals		2,446	2,446
New.			
American Zinc & Chem. Co.	Langeloth, Penn.	.....	864
Granby Mining & Sm. Co.	E. St. Louis, Ill.	.....	3,240
Totals		.....	4,104
Grand totals		109,570	119,606

(*a*) Inactive throughout year. (*b*) Inactive during latter part of year. (*c*) Plant being dismantled. (*d*) No report received; entered the same as last year.

spelter than in 1914. In addition thereto there was a new plant of 17,500 tons capacity (terms of tons of spelter) immediately available, and furnaces of nearly 11,500 tons capacity in construction and so far advanced as to become available early in 1915. There were also two inactive plants possessing a capacity of about 10,000 tons. This does not include the moribund works of Kansas, which may or may not be put into use. They had a capacity of about 62,000 tons.

The United States possesses therefore, or very soon will possess, first-

class capacity for the production of 445,000 tons of spelter per annum, and second-class capacity amounting to 72,000 tons additional that may be used in emergency. These figures take no account of the dross and scrap smelters.

The estimate of a maximum capacity for 517,000 tons of spelter must be discounted, however, being based on the average yield in a year of low price when the ore treated was probably of a relatively high grade. The high price for spelter will draw out lower grade ore and the average yield per retort will be lower. Moreover, the roasting capacity of American smelters is materially short of their distillation capacity, which means that they may not be able to attain the maximum use of their distillation furnaces unless they can secure all the calamine ore that they need, and calamine ore is generally of lower grade than blende. It is best not to undertake to draw fine points, but simply to assume that the smelting capacity of the United States is largely in excess of any use of it previous to the end of 1914.

Imports and Exports.—In 1914 there was a larger exportation of spelter than ever before in the history of the United States, the total being 70,242 tons, including 5580 tons of spelter smelted in bond. The government figures of the exportation of bonded spelter are a little different from those reported by the smelters. However, this is explained by difference of the period comprised within the respective reports.

IMPORTS AND EXPORTS, BY QUARTERS

Imports.	Ore, Long Tons.	Spelter, Lb.	Dust, Lb.
I	3,355	500,253	1,288,259
II	4,727	512,123	1,256,559
III	6,849	664,012	535,161
IV	31,329	83,191	1,524,128
Year	46,260	1,759,579	4,604,107
Exports.	**Ore, Long Tons.**	**Spelter, Lb.**	**Dross.**
I	2,883	842,465	572,477
II	4,297	769,560	0
III	1,319	48,280,632	1,239,570
IV	1,421	90,591,936	3,239,020
Year	9,920	140,484,593	5,051,067

The government reported the importation of 28,050 long tons of zinc ore in 1913 and 46,260 long tons in 1914. The former figure checked with the smelters' reports of receipts; the latter is much in excess thereof. The difference may be in part explained by an increased supply of incoming ore not yet received by the smelters at the end of 1914.

The exports of zinc ore from the United States dropped from 15,815 long tons in 1913 to 9920 long tons in 1914. This was due chiefly to the

impossibility of exporting New Jersey willemite to Belgian and German smelters after the outbreak of the war.

Deliveries.—Estimated deliveries are given in an accompanying table. Deliveries are computed by difference between (*A*) stocks, plus pro-

DELIVERIES FOR CONSUMPTION

	1910.	1911.	1912.	1913.	1914.
Stock, Jan 1	11,500	23,000	9,323	4,264	40,115
Production	288,415	309,336	363,638	378,762	380,361
Imports	3,452	1,637	11,115	6,100	880
Totals	303,367	333,973	384,076	389,126	421,356
Exports, domestic	3,989	6,872	6,634	7,782	64,802
Exports, foreign	4,468	11,270	8,700	6,526	5,580
Stock, Dec. 31	23,000	9,323	4,264	40,115	23,500
Deliveries	271,892	316,508	364,488	334,703	327,474

duction, plus imports, and (*B*) exports plus stocks, but experience shows how futile it is to attempt to compute consumption in that way, and how important a part is played by the stocks in the yards of galvanizers and brass makers, the invisible supply.

The statistics in the table of deliveries are incomplete because of their omission of stocks held by dross smelters. Moreover the statistics of stocks and exports, the former reported by the smelters as what was at their works and the latter reported by the government as what was shipped abroad from our ports, do not register exactly. The exports reported in December would register approximately with the stock at the end of November, at which time the stock at smelteries was undoubtedly higher than at the end of December. In other words, the deliveries in 1914 computed by the only method available, which is admittedly imperfect, are probably larger than in fact they were.

Deducting from the total production the amount that was derived from dross and skimmings, and adding 90 per cent. of the production of zinc dust, the zinc yield of 855,435 tons of ore smelted in 1914 was 41 per cent., corresponding to average grade of 47½ per cent. Zn for the ore, assuming an average extraction of 86 per cent. We do not possess corresponding figures for 1913 and therefore can not make any comparison. In view of the low price prevailing in 1914 it is not an unreasonable surmise that the average grade of the ore coming to the smelters was higher than usual. The decrease in ore receipts indicates that the miners felt the pinch of low prices. Even so there was less ore smelted than was taken in, which is easily explained in part by the necessary accumulation of stocks at two new smelting works. The large increase in imports of ore in the fourth quarter and the difference between the government report of imports and the smelters' reports of foreign receipts indicate that a large quantity of foreign ore was in transit at the end of the year. The exports

of spelter in December amounted to the huge figure of 20,192 tons, as reported by the government.

A surprising feature of the statistics for 1914 is the large proportion of calamine smelted in this country. Not requiring roasting, this is a particularly desirable class of ore for the smelters of Kansas and Oklahoma whose gas supply is scanty.

The statistics of imports and exports by quarters reveal some of the interesting effects of the war in the cases of spelter, dross and ore exports and zinc-dust imports.

AVERAGE MONTHLY PRICE OF SPELTER PER POUND IN ST. LOUIS

Year.	Jan.	Feb.	Mar.	April.	May.	June.	July.	Aug.	Sept.	Oct.	Nov.	Dec.	Year.
	Cts.	Cts.	Cts.	Cts.	Cts.	Cts.	Cts.	Cts.	Cts.	Cts.	Cts.	Cts.	Cts.
1905....	6.032	5.989	5.917	5.667	5.284	5.040	5.247	5.556	5.737	5.934	5.984	6.374	5.730
1906....	6.337	5.924	6.056	5.931	5.846	5.948	5.856	5.878	6.056	6.070	6.225	6.443	6.048
1907....	6.582	6.664	6.687	6.535	6.291	6.269	5.922	5.551	5.086	5.280	4.775	4.104	5.812
1908....	4.363	4.638	4.527	4.495	4.458	4.393	4.338	4.556	4.619	4.651	4.909	4.987	4.578
1909....	4.991	4.739	4.607	4.815	4.974	5.252	5.252	5.579	5.646	6.043	6.231	6.099	5.252
1910(a)	5.951	5.419	5.487	5.289	5.041	4.978	5.002	5.129	5.364	5.478	5.826	5.474	5.370
1911(a)	5.302	5.368	5.413	5.249	5.198	5.370	5.545	5.803	5.719	5.951	6.223	6.151	5.608
1912(a)	6.292	6.349	6.476	6.483	6.529	6.727	6.966	6.878	7.313	7.276	7.221	7.081	6.799
1913(a)	6.854	6.089	5.926	5.491	5.256	4.974	5.128	5.508	5.554	5.188	5.083	5.004	5.504
1914(a)	5.112	5.228	5.100	4.963	4.924	4.850	4.770	5.418	5.230	4.750	4.962	5.430	5.061

(a) From *Eng. Min. Jour.*

AVERAGE MONTHLY PRICE OF SPELTER PER POUND IN NEW YORK

Year.	Jan.	Feb.	Mar.	April.	May.	June.	July.	Aug.	Sept.	Oct.	Nov.	Dec.	Year.
	Cts.	Cts.	Cts.	Cts.	Cts.	Cts.	Cts.	Cts.	Cts.	Cts.	Cts.	Cts.	Cts.
1902....	4.27	4.15	4.28	4.37	4.47	4.96	5.27	5.44	5.49	5.38	5.18	4.78	4.84
1903....	4.87	5.04	5.35	5.55	5.63	5.70	5.66	5.73	5.69	5.51	5.39	4.73	5.40
1904....	4.863	4.916	5.057	5.219	5.031	4.760	4.873	4.866	5.046	5.181	5.513	5.872	5.100
1905....	6.190	6.139	6.067	5.817	5.434	5.190	5.396	5.706	5.887	6.087	6.145	6.522	5.882
1906....	6.487	6.075	6.209	6.078	5.997	6.096	6.006	6.027	6.216	6.222	6.375	6.593	6.128
1907....	6.732	6.814	6.837	6.685	6.441	6.419	6.072	5.701	5.236	5.430	4.925	4.254	5.960
1908....	4.518	4.788	4.665	4.645	4.608	4.543	4.485	4.702	4.769	4.801	5.059	5.137	4.726
1909....	5.141	4.889	4.757	4.965	5.124	5.402	5.402	5.729	5.796	6.199	6.381	6.249	5.503
1910(a)	6.101	5.569	5.637	5.439	5.191	5.128	5.152	5.279	5.514	5.628	5.976	5.624	5.539
1911(a)	5.452	5.518	5.563	5.399	5 348	5.520	5.695	5.953	5.869	6.102	6.380	6.301	5.734
1912(a)	6.442	6.499	6.626	6.633	6.679	6.877	7.116	7.028	7.454	7.426	7.371	7.162	6.943
1913(a)	6.931	6.239	6.078	5.641	5.406	5.124	5.278	5 658	5.694	5.340	5.229	5.154	5.648
1914(a)	5.262	5.377	5.250	5.113	5.074	5.000	4.920	5.568	5.380	4.909	5.112	5.592	5.213

(a) From *Eng. Min. Jour.*

AVERAGE MONTHLY PRICE OF SPELTER IN LONDON
(Pounds sterling per ton of 2240 lb. of good ordinary brands)

Year.	Jan.	Feb.	Mar.	April.	May.	June.	July.	Aug.	Sept.	Oct.	Nov.	Dec.	Year.
	£.	£.	£.	£.	£.	£.	£.	£.	£.	£.	£.	£.	£.
1907....	27.125	25.938	26.094	25.900	25.563	25.469	23.850	21.969	21.050	21.781	21.438	20.075	23.771
1908....	20.563	20.875	21.075	21.344	19.906	19.000	19.031	19.350	19.563	19.750	20.875	20.625	20.160
1909....	21.425	21.563	21.438	21.531	21.975	22.000	21.969	22.125	22.906	23.200	23.188	23.094	22.185
1910(a).	23.350	23.188	23.031	22.469	22.100	22.094	22.406	22.800	23.165	23.900	24.083	24.019	23.050
1911(a).	23.887	23.276	23.016	23.743	24.375	24.612	25.006	26.801	27.750	27.256	26.795	26.849	25.281
1912(a).	26.642	26.661	26.048	25.644	25.790	25.763	26.174	26.443	27.048	27.543	26.804	26.494	26.431
1913(a).	26.114	25.338	24.605	21.313	24.583	22.143	20.592	20.706	21.148	20.614	20.581	21.214	22.748
1914(a).	21.533	21.413	21.460	21.569	21.393	21.345	21.568	(b)	(b)	(b)	25.016	27.369	.....

(a) From *Eng. Min. Jour.*
(b) Not reported.

PRODUCTION AND CONSUMPTION STATISTICS

The following tables, compiled by C. E. Siebenthal and published by the United States Geological Survey, are as authentic as can be obtained, and give the production of primary and secondary spelter in the United States, consumption of primary spelter in the United States, as well as exports and imports of zinc ore.

PRODUCTION OF SPELTER IN 1914
(In tons of 2000 lb.)

	1913.	1914.	Change in 1914.	
			Quantity.	Percentage.
Production of primary spelter in the United States	346,676	353,049	+ 6,373	1.8
Consumption of primary spelter in the United States	295,370	299,130	+ 3,760	1.2
Production of spelter in the world	1,031,359	.....	.....	.....

PRODUCTION OF PRIMARY SPELTER[1] IN THE UNITED STATES, 1909–1914
(In tons of 2000 lb.)
Apportioned According to Source of Ore

	1909.	1910.	1911.	1912.	1913.	1914.
UNITED STATES:						
Arizona	2,862	2,594	2,336	4,092	4,675	3,905
Arkansas	135	286	385	604	478	670
California	.....	.....	1,099	1,672	1,012	159
Colorado	20,121	23,238	42,233	60,841	58,113	41,746
Idaho	901	3,454	3,180	6,800	10,190	22,720
Illinois	675	1,551	2,884	3,952	1,345	1,833
Iowa	.....	40	.....	.....	.....	.....
Kansas	9,185	10,220	6,843	5,668	9,956	10,634
Kentucky	22	29	205	394	172	147
Maine	.....	.....	.....	.....	.....	.....
Missouri	140,676	140,652	127,540	149,557	129,018	114,019
Montana	4,725	12,408	22,115	14,196	35,604	55,986
Nevada	825	1,516	1,595	6,132	5,828	6,041
New Jersey	16,035	20,217	15,128	16,941	24,247	27,734
New Mexico	3,961	4,911	3,778	6,882	3,765	4,345
Oklahoma	3,008	2,297	2,247	2,041	6,397	9,449
Tennessee	695	925	1,000	1,935	2,635	6,122
Texas	.....	.....	.....	245	303	156
Utah	5,960	7,221	7,004	7,756	9,503	6,818
Virginia	58	1,168	228	62	116	20
Washington	.....	.....	12	.....	.....	.....
Wisconsin	20,381	19,752	31,809	34,137	33,743	30,914
Total domestic	230,225	252,479	271,621	323,907	337,252	343,418
FOREIGN:						
Canada	978	3,304	1,598	4,199	1,424	4,538
Mexico	24,557	13,401	13,307	10,700	6,205	5,093
Europe	.....	.....	.....	.....	1,175	.....
Siberia	.....	.....	.....	.....	620	.....
Total foreign	25,535	16,705	14,905	14,899	9,424	9,631
Grand total	255,760	269,184	286,526	338,806	346,676	353,049
Apportioned According to Locality in which Smelted						
Illinois	67,653	73,038	83,130	88,397	106,654	127,946
Kansas	103,299	105,697	98,413	101,104	74,106	44,510
Oklahoma	28,782	34,760	46,315	76,925	83,214	91,367
Other states	56,026	55,689	58,668	72,380	82,702	82,226
Total	255,760	269,184	286,526	338,806	346,676	353,049

[1] Primary spelter is made directly from ore, but secondary spelter is recovered from such sources as drosses, skimmings, and old metals.

PRODUCTION OF SECONDARY ZINC IN THE UNITED STATES, 1909–1914

Secondary spelter, re-distilled	9,273	12,784	14,043	26,064	[1]25,991	20,545
Secondary spelter, re-melted	23,767	28,439	26,470	26,187	[1]24,014	22,070
Recovered zinc in alloys, excluding old brass re-melted	1,181	2,709	3,223	3,912	[1]3,743	3,800

[1] Subject to final revision.

WORLD'S PRODUCTION OF SPELTER 1909–1914

	1909.	1910.	1911.	1912.	[1]1913.	1914.
Locality in which smelted:						
Australia	.....	560	1,904	2,531	4,105	Foreign countries not yet available.
Austria and Italy	13,931	14,666	18,602	21,609	23,856	
Belgium	184,194	190,233	215,050	220,678	217,941	
France and Spain	61,859	65,191	70,791	79,543	78,293	
Germany	242,594	251,046	276,008	298,794	311,914	
Great Britain	65,422	69,531	73,803	63,086	65,201	
Holland	21,548	23,121	25,059	26,380	26,813	
Norway	.....	.....	7,363	8,959	19,040	
Poland	8,758	9,514	10,952	9,659	9,520	
United States	255,760	269,184	286,526	338,806	346,676	
Total	854,066	893,046	986,058	1,070,045	1,103,359	
United States percentage of world's production	29.9	30.1	29.1	31.7	31.4	

[1] Subject to final revision.

CONSUMPTION OF PRIMARY SPELTER IN THE UNITED STATES, 1909–1914

	1909.	1910.	1911.	1912.	1913.	1914.	
						First Half.	Second Half.
Supply:							
Stock, Jan. 1—							
In bonded warehouses	9	39	31	32	48	.....	.....
At smelters	19,613	11,167	23,201	9,049	4,474	40,659	64,039
Production—							
From domestic ore	230,225	252,479	271,621	323,907	337,252	171,496	171,923
From foreign ore	25,535	16,705	14,905	14,899	9,424	3,562	6,039
Imports	9,454	1,960	609	11,115	6,100	506	374
Total available	284,836	282,350	310,367	359,002	[1]357,298	216,223	242,404
Withdrawn:							
Exports, foreign, from warehouse	334	4,758	11,276	6,286	6,027	167	5,413
Exports, foreign, under drawback	.....	4,486	3,079	1,188	7,459	1,881	3,100
Exports, domestic	2,566	3,990	6,872	6,634	7,783	773	64,039
Stock, Dec. 31—							
In bonded warehouses	39	31	32	48	.....	.....	111
At smelters	11,167	23,201	9,049	4,474	40,659	64,039	19,894
Total withdrawn	14,106	36,466	30,308	18,630	61,928	66,860	92,657
Apparent consumption	270,730	245,884	280,059	340,372	295,370	149,363	149,747
						299,130	

NOTE.—Imports and exports of spelter are given under the heading "Consumption." The imports of spelter in 1909–1913 are as given in the December Summary of the Bureau of Foreign and Domestic Commerce except that for 1909–1912 inclusive; the quantities given therein have been diminished by the quantity of zinc dust imported since Aug. 6, 1909, for the reason that the imports of spelter and zinc dust were not separated in the Summary. The imports of spelter are also exclusive of sheet zinc. The stock in bonded warehouses does not include zinc ore in bond or the spelter made therefrom, such spelter being included in stock at smelters.

EXPORTS OF ZINC ORE AND ZINC OXIDE FROM THE UNITED STATES (a)

r.	Ore.			Oxide.		
	Short tons.	Value.	Value per ton.	Short tons.	Value.	Value per ton.
...	42,062	$1,134,663	$26.98	5,656	$496,380	$87.76
...	44,146	1,167,684	26.45	4,561	393,259	86.22
...	55,733	1,449,104	26.00	5,358	433,722	80.93
...	39,411	987,000	25.04	7,215	578,215	80.14
...	35,911	905,782	25.22	8,157	628,494	77.05
...	30,946	848,451	27.41	11,280	810,203	71.83
...	27,720	733,300	26.45	15,578	1,149,297	73.78
...	20,352	579,490	28.47	13,256	1,069,924	80.71
...	26,108	877,745	33.60	12,008	845,070	70.37
...	12,456	412,300	33.10	14,846	1,026,377	69.14
...	19,711	649,425	32.95	13,166	943,968	71.69
...	18,281	642,884	44.12	14,618	1,051,311	71.92
...	23,349	823,997	35.30	17,064	1,247,702	73.12
...	17,712	631,991	35.68	14,466	1,136,257	78.55
...	11,110	388,464	34.96	15,592	1,408,525	90.34

) In addition to the exports of ore, 15,887 short tons of zinc dross (galvanizers' waste) was ex- l in 1906, 9593 tons in 1907, 8405 tons in 1908, 7069 tons in 1909, 4728 tons in 1910, 4246 tons 1, 205 tons in 1912, 28 tons in 1913, and 2,026 tons in 1914.

EXPORTS OF DOMESTIC SPELTER FROM THE UNITED STATES (a)

Year.	Plates, Sheets, Pigs and Bars.		Wares.	Total Value.
	Short Tons.	Value.	Value.	
.....	6,755	$742,521	$143,232	$885,753
.....	22,411	2,217,963	99,288	2,317,251
.....	3,390	228,906	82,046	310,952
.....	3,237	300,557	114,197	414,754
.....	1,521	163,379	71,354	234,733
.....	10,073	1,094,490	117,957	1,212,447
.....	5,516	682,254	159,995	842,249
.....	4,670	583,526	204,269	787,795
.....	563	75,526	186,283	261,809
.....	2,640	250,254	88,485	338,739
.....	2,566	263,010	69,751	332,761
.....	3,990	426,560	101,336	527,896
.....	6,872	810,099	134,518	944,617
.....	6,634	864,292	140,027	1,004,319
.....	7,782	955,667	145,984	1,101,651
.....	64,802	8,540,668	210,974	8,751,642

There is also a comparatively insignificant re-export of foreign-made spelter and zinc wares.

IMPORTS OF ZINC AND ZINC OXIDE INTO THE UNITED STATES
(In pounds)

	Sheets, Blocks, Pigs and Old.		Manufactures.	Total Value.	Oxide.	
	Amount.	Value.			Dry.	In Oil.
.	2,985,463	$151,956	$14,800	$166,756	3,012,709	41,699
.	2,013,196	97,772	36,836	134,608	2,618,808	38,706
.	775,881	30,920	42,643	73,563	3,199,778	128,198
.	1,238,091	46,713	37,191	83,904	3,271,385	163,081
.	728,614	30,900	18,938	49,838	3,487,042	166,034
.	933,474	44,326	11,918	56,244	2,585,661	224,244
.	1,042,081	51,052	12,390	63,442	3,436,367	342,944
.	4,407,481	253,310	17,385	270,695	4,191,476	292,538
.	3,555,890	210,322	16,282	226,604	5,311,318	362,418
.	1,762,627	85,885	7,474	93,359	4,635,101	210,166
.	19,340,029	826,588	19,176	845,764	6,119,328	535,024
.	6,904,389	289,689	27,475	317,164	6,133,840	336,257
.	3,275,340	170,634	124,983	295,617	(a)5,561,016	.....
.	22,229,831	1,280,426	293,089	1,573,515	(a)5,875,057	.....
.	12,199,267	660,706	62,256	(b) 722,962	6,580,944	284,150
.	1,759,579	71,165	31,724	(b) 102,889	6,798,550	424,287

Both dry and in oil.
Zinc dust to the amount of 4,382,470 lb., valued at $227,585, was also imported in 1913, and 107 lb., valued at $218,338, in 1914.

IMPORTS OF ZINC ORE, 1905–1914

	Canada.		Mexico.		Total.[1]	
	Ore.	Zinc Content.	Ore.	Zinc Content.	Ore.	Zinc Content.
1905	4,063	.....	18,074	.....	22,137	.....
1906	423	.....	59,991	.....	60,414	.....
1907	1,112	.....	102,005	.....	103,117	.....
1908	7,406	.....	46,351	.....	53,757	.....
1909	10,024	.....	104,826	.....	114,850	.....
1910	4,749	1,922	67,818	23,517	72,567	25,439
1911	2,359	947	36,847	14,986	39,206	15,933
1912	8,015	3,661	35,925	14,206	43,940	17,867
1913	8,357	3,280	18,018	6,377	26,375	9,657
1914	11,250	4,467	20,705	7,663	31,962	12,132

[1] Includes also 3232 tons of ore from Europe, containing 2440 tons of zinc and 1792 tons from Siberia, containing 1397 tons of zinc.

EXPORTS OF DOMESTIC SPELTER AND SHEETS, 1914

	Pounds.	Value.		Pounds.	Value.
1914.			1914.		
January	459,703	$25,827	July	313,166	16,315
February	35,550	3,233	August	6,896,504	479,263
March	292,094	18,471	September	38,090,144	2,479,442
April	120,149	7,939	October	20,517,926	1,484,686
May	214,201	13,618	November	25,493,697	1,657,373
June	425,210	31,569	December	36,642,727	2,322,943

"The statistics of general imports, as published by the Bureau of Foreign and Domestic Commerce, are based on 'consular invoice' or 'declaration,' which is a close approximation only to actual weights and values. The true weights and values of all dutiable articles are determined when the duties are paid, and the correction is applied as 'addition by liquidation' or 'deduction by liquidation.' On free articles this correction is not made. Prior to 1909 zinc ore was in large part undutiable, and in that part of 1909 prior to August 6 a portion of the imports on zinc ore was free. The quantities added or deducted by the liquidation changes are known, and if applied to the consular invoice figures should theoretically give the true figures of imports, and this correction has been made in preceding reports. It has been ascertained, however, that for one customs district the returns, under special instructions, are made in such form that the use of the liquidation corrections involves a considerable duplication. For this reason no correction of the consular invoice figures has been attempted in the present statement. The figures are exclusive of 10,431 tons of other ore imported in 1910, which carried 2,645,111 lb. of zinc as an accessory constituent, of 25,769 tons in 1911 carrying 6,283,437 lb. of zinc, and of 18,245 tons in 1912 carrying 4,862,508 lb. of zinc, an average of about 13 per cent. which is not recoverable and hence, for the purpose of this report, not to be classed

with zinc-ore imports. Such ores have entered free since 1913 and are not enumerated.

"The figures of spelter production do not include the zinc content of zinc pigments produced during the year, except such as are made from spelter by the French process.

"The figures given in the foregoing tables are based on confidential reports by each zinc-smelting company in operation in the United States. The totals of production in foreign countries are taken from the annual statement by Henry R. Merton & Co., of London. The figures of imports and exports are taken from the records of the Bureau of Foreign and Domestic Commerce of the Department of Commerce, re-calculated to short tons, and those for 1914, not having been finally checked, are subject to minor revision."[1]

Zinc Mining in the United States

Arizona.—The production of spelter for 1914 was 3905 tons, a decrease of 770 tons from the figures for 1913. The Golconda and Tennessee mines of the Chloride district were large producers, the former shipping about 40 tons of high-grade zinc concentrate daily. The Empire Zinc Co. has done considerable development work on the San Xavier mine in the Twin Buttes district.

Arkansas.—The spelter production for the state is estimated at 670 tons for 1914, as against 478 tons in 1913. Much of the sphalerite concentrates was mixed sphalerite and carbonate ore, the zinc content averaging a little over 40 per cent., notably the output of the Morning Star and Smuggler mines in Marion County. The Sure Pop mine was the largest producer of carbonate ore. The Frisco, Almy, Coon Hollow, Coker Hollow, and Barham mines of Boone County were worked extensively during the year.

California.—The production of spelter from this state during 1914 was the smallest for several years, being given by the U. S. Geological Survey as 159 tons, as against 1012 tons for the revised statistics for 1913. The Shasta copper field promises to produce considerable spelter in the future, if metallurgical processes now being tried out prove successful. At present the 15–20 per cent. zinc content of the ores is a detriment rather than an asset.

Colorado.—The zinc production of Colorado for 1914 shows a marked decrease from the figures for 1913, being but 41,746 tons, the lowest figure since 1910. As usual, most of the zinc was mined in Lake Countyin, which Leadville is by far the largest producer, although in the figures for Lake

[1] C. E. Siebenthal, U. S. Geological Survey.

County, production from Lackawanna Gulch and St. Kelvin district is included. These figures show 39,500 tons of zinc for 1914, against 46,922 for 1913. The output of zinc carbonate was 111,000 tons of 24.7 per cent. zinc, against 135,760 tons of 27.45 per cent. zinc content in 1913. The zinc carbonate was mostly smelted outside of the state, although a small zinc oxide plant was operated for a while at Leadville. The sulphide ores were treated at the Empire Zinc Co.'s magnetic plant at Canon City, at the Western Chemical Co.'s sulphuric acid wet concentration and magnetic separation plant at Denver, at the United States Zinc Co.'s plant at Pueblo, and at other concentrators and smelters. The Leadville district mill was remodeled and the Minerals Separation flotation equipment added.

San Juan, San Miguel, and Dolores Counties all show heavy decreases in zinc production. Chaffee County produced about the same amount of zinc as in 1913, while Clear Creek County showed a marked decrease, as did also Creede County. Gunnison County, owing chiefly to heavy output of lead-zinc from Whitepine, shows a marked increase, the figure for 1914 being 2500 tons of zinc. Eagle County, chiefly due to Red Cliff, is credited with 3832 tons, a gain of 500 tons.

Idaho.—This state is rapidly coming to the front as a zinc producer, as is shown by its output of 22,720 tons for 1914, more than twice that of 1913. The great increase is due largely to the Interstate-Callahan mines, near Wallace, which now rank as one of the large zinc producers of the world. Here a large body of high-grade sphalerite, low in lead, has been developed, and production is being accelerated. The present mill is unable to handle the output of the mine, and a new milling plant is being planned. The Success mine also contributed largely in the production figures for the state.

Illinois.—The Marsdon-Black Jack, Vinegar Hill, North Unity, Northwestern, and Pittsburgh mines were actively operated, and the production of sphalerite concentrates amounted to 16,725 tons, valued at $320,012, an increase of 8577 tons over the 1913 output, according to the U. S. Geological Survey. In no year since 1907 has the output been so large, although the value has been exceeded. The quantity of crude ore treated increased about 142,000 tons, and the blende concentrates were 1.7 per cent. higher in average zinc content, so that the average price for such concentrates was nearly equal to that paid in 1913.

Kansas.—The latest available figures place the production of spelter at 11,284 tons, a slight gain over 1913. The Kansas production of sphalerite concentrates increased from 20,003 tons, valued at $793,034 in 1913, to 21,812 tons, valued at $830,176, in 1914. This large increase was due largely to the doubling of the output of the Lawton district, which

produced high-grade concentrates. The carbonate ores were of relatively little importance, only 38 tons being listed, this coming from the Galena district.

Kentucky.—The recoverable zinc content of concentrates produced in the state was 230 tons, valued at $23,460, compared to 372 tons, valued at $36,624, in 1913. Only 27 tons of sphalerite and 644 tons of carbonate ore were credited to this state by the U. S. Geological Survey. These were produced by the Commodore and Miller mines in the Marion district, and the American Spar Co. of Salem.

Missouri (Joplin district).—The following extract from the review by Jesse A. Zook of the Joplin District for 1914, as published in the *Engineering and Mining Journal*, covers the production and mining conditions in general.

As indicated in the review of 1913, sheet-ground mines were gradually abandoned, weeding out all but the best. The extreme low level of prices during May, June, July, and early August extended over a period of too great length for the thinner ones to withstand.

Three areas increased production, Alba-Neck in Missouri, Lawton in Kansas, and Miami-Commerce in Oklahoma. The two former are known as "free-ore" deposits. The latter is largely a free horizontal vein, with dips, chimneys, and pockets equaling free-ore deposits.

Variations in Prices.—The range in high prices of blende was: January opened $45, closed $44; February opened $45, closed $46; March opened $43.50, closed $43; April and May saw nothing over $43, but June closed $44; July opened $42, closed $41.50; August opened $42.50, closed $53; September opened $50, closed $44; October opened $45, closed $49; November declined to $47, rising to close $48.50; weekly increases during December brought the year to a close with blende very strong around $50 to $52—$5 to $7 per ton higher than the year's opening.

JOPLIN DISTRICT ORE SHIPMENTS, IN POUNDS

	Blende.	Calamine.	Lead.	Values.
Missouri:				
Jasper County	375,804,640	1,807,100	60,383,410	$1,412,450
Newton County	25,263,270	33,439,290	4,850,770	955,110
Lawrence County	391,500	4,062,770	250,740	64,050
Other counties	679,000	116,000	.....	15,570
Total	402,138,410	39,425,170	65,494,920	$10,153,790
Oklahoma:				
Ottawa County	63,430,820	.....	16,898,880	1,566,950
Kansas:				
Cherokee County	43,506,660	.....	4,860,200	1,001,470
Total 1914 (a)	509,075,490	39,425,170	87,254,000	12,722,210
Total 1913	554,162,910	43,383,770	95,779,640	15,272,330
Decrease	45,155,420	3,958,600	8,525,640	2,550,120

(a) December estimated for each county.

January, February, and March brought a comparatively even high price level of $51.50 to $54; April opened $53, closed $47; May, June, July, August, and September price level was between $47 and $48.50; October opened $48, closed $42; November opened $43.50, closed $49. A lower pig-lead market came with December, but galena was not changed in price.

All the developed mines in the Carthage area were abandoned in October, and low prices retarded prospecting for new ore reserves. Sar-

ORE PRICES IN JOPLIN DISTRICT
(14 years)

Year.	Zinc Ore.		Lead Ore.	
	High.	Average.	High.	Average.
1901	$34.00	$24.21	$47.50	$45.99
1902	42.00	30.33	50.00	46.10
1903	42.00	33.72	60.50	54.12
1904	53.00	35.92	62.00	54.80
1905	60.00	44.88	80.00	62.12
1906	54.00	43.30	87.00	77.78
1907	53.50	43.68	88.50	68.90
1908	47.00	34.36	66.50	54.66
1909	55.00	41.08	60.50	54.56
1910	52.00	40.42	58.00	51.98
1911	51.00	39.90	64.00	56.76
1912	67.00	52.15	68.00	56.60
1913	53.16	42.62	57.78	52.82
1914	50.50	39.43	50.88	46.55

coxie had an intermittent career, declining until July when a revival came with developments that forecast a widening of the developed area and an increased production. Carl Junction dwindled from 750 tons per month in January to 100 tons at the year-end. Oronogo shipments weakened in September but came out stronger at the close than the beginning of the year. Wentworth skipped shipments in June, July, and August, coming back in September. Aurora operations are on upper levels and the production principally calamine, with some blende and galena. Quapaw, once promising, is a small factor now from lack of systematic development.

The closing of some large mills, with the men out of employment, resulted in the unemployed seeking shallow abandoned workings, a factor preventing a greater decrease in the production. Blende-galena revivals in shallow workings extend from Lone Elm hollow across Possum hollow, Chitwood hollow, Leadville hollow, East and West hollows to Zincite, all to the northwest of Joplin. Southeast of Joplin came a growth in calamine production from shallow workings in the north edge of Newton County. Across Shoal Creek, farther south, old workings were revived and new mines developed with a mixed output of calamine and galena.

Miami-Commerce.—With the establishment of a town site and the rapid building of the town of Commerce, 5 miles north of Miami, the old mining camp of Hattenville was absorbed in the upspringing of the incorporated town. New developments of this area are mainly to the north of Commerce. A drilling campaign progressed throughout the year, closing with 30 outfits in operation. One mill is in operation and another building 3 miles northeast of Commerce, on shaft development that predicts an even greater ore-body than the older mines.

The Picher Lead Co., of Joplin, holds leases on 2700 acres of land north of Commerce to the Kansas state line, on which nine drilling outfits are continuously at work. While exact records are not at hand, current report is that a wide range of the zinc-lead deposit was encountered, carrying 16 per cent. blende and 7 per cent. galena.

The following table, giving production by districts, has been compiled by J. P. Dunlop of the U. S. Geological Survey:

District.	Zinc Concentrates.					
	Sphalerite.		Silicate and Carbonate.		Zinc. (a.)	
	Quantity.	Value.	Quantity.	Value.	Quantity.	Value.
Southwestern Missouri:						
Alba-Neck City	24,738	$1,042,303	614	$12,180	13,512	$1,378,224
Ash Grove-Everton	.....	.....	120	1,440	34	3,468
Aurora	246	6,290	2,154	46,252	875	89,250
Carl Junction	3,847	146,792	.....	.....	2,032	207,264
Carthage	1,889	76,139	65	1,364	1,040	106,080
Cave Springs	2,652	112,602	.....	.....	1,426	145,452
Duenweg-Porto Rico	19,526	760,790	169	3,058	10,216	1,042,032
Granby	4,812	197,042	10,398	246,280	6,170	629,340
Joplin	36,437	1,403,476	2,080	42,063	20,022	2,042,244
Oronogo	9,472	391,334	.....	.....	5,134	523,668
Sarcoxie-Reeds	941	39,465	185	4,000	577	58,854
Sherwood-Thomas Station	9,536	327,000	18	154	4,588	467,976
Spring City-Beef Branch	3,581	120,973	1,397	24,585	2,167	221,034
Springfield	1,898	85,117	.....	.....	1,073	109,446
Spurgeon	1,223	43,499	7	148	636	64,872
Webb City-Carterville-Prosperity	64,089	2,414,476	.....	.....	33,305	3,397,110
Wentworth and Stott City	917	36,680	100	2,300	532	54,264
Zincite and Klondike	3,921	147,048	.....	.....	2,002	204,204
Christian and Ozark Counties	.....	.....	1,844	20,079	468	47,736
	189,725	$7,351,026	19,151	$403,903	105,809	$10,792,518
Central and southeastern Missouri	40	700	497	11,282	185	18,870
State total: 1914	189,765	$7,351,726	19,648	$415,185	105,994	$10,811,388

(a) In calculating the metal content of the ores from assays allowance has been made for smelting losses in the case of zinc. In comparing the values of ore and metal it should be borne in mind that the value given for the ore is that actually received by the producer, whereas the value of the metal is calculated from the average daily quotations at New York and St. Louis.

Montana.—This state again shows a large gain, the record figure of 35,604 tons of spelter in 1913 being eclipsed by a new record of 55,986 tons for 1914. The great increase is due principally to the production

of the Butte & Superior and Timber Butte mills, the latter handling the output of the Elm-Orlu mine, starting operation in July, with a daily capacity of 500 tons per day, using flotation following table concentration. From 313,874 tons of ore mined and milled, the Butte & Superior Co. produced 98,200 tons of zinc concentrates, assaying 53.27 per cent. zinc and 25.5 oz. silver; and 4000 tons of lead-zinc concentrate, assaying 45.64 per cent. lead, 13.72 per cent. zinc, and 42.8 oz. silver.

Nevada.—During the year, 6041 tons of zinc was produced, against 5828 in 1913, the production as usual coming principally from the Yellow Pine district. The Yellow Pine Mining Co. operated its plant at about two-thirds capacity throughout the year, producing 2200 tons of lead concentrates, 11,000 tons of zinc concentrates, and 1000 tons of crude zinc ores. At the Frederickson property considerable mixed carbonate ore was developed. Other properties which shipped zinc carbonate ores were the Mountain Top, Mobile, Anchor, Monte Cristo, Bullion, and Bill Nye.

New Jersey.—All of the zinc from New Jersey is produced by the New Jersey Zinc Co. from its mines at Franklin Furnace and Stirling Hill, N. J. The state is credited in the U. S. Geological Survey report with 27,734 tons of zinc in 1914, against 24,247 in 1913. However, the total recoverable zinc in the ore mined was greater than this figure, as much of the ore is converted into zinc oxide for pigment. Development at the old workings at Stirling Hill is progressing satisfactorily, and in the future this part of the property will aid materially in production.

New Mexico.—The production of the state is given as 4345 tons of spelter in 1914, a gain over 1913. Owing to the low price of zinc and lead, some of the companies were closed down part of the year, the Ozark Smelting and Mining Co., operating the Graphic mine and a surface tension flotation plant near Magdalena, being the only one in the district to operate continuously. This mill treated about 40,000 tons of ore. The Empire Zinc Co., after purchasing the property of the Tri-Bullion Co. at Kelly, pursued development steadily and remodeled the concentrator, which will be ready in 1915. The Juanita, operated by the MacDonald Co., made considerable output of carbonate ore.

Oklahoma.—The principal zinc mines in Oklahoma are all located in Ottawa County and the Miami is the only active camp at present, although some mining is being done at the Lincolnville and Peoria camps. The low prices in the early part of 1914 were the cause of extensive curtailment of production, but with later rise in price production has increased. During the year a great amount of prospecting by drilling was done. The Picher Lead Co. and the Commerce Mining & Royalty Co. have led in this work, and at the present time five different shafts are being put down

to the ore-bodies that have been proved. The Cornfield Mining Co. has just completed a modern mill. The Zinc Issues Co. has done some drilling and proved that there is a run of ore at 380 ft. in depth. According to the U. S. Geological Survey, the recoverable spelter increased from 11,664 tons, valued at $1,306,368, in 1913 to 13,992 tons, valued at $1,427,184, in 1914.

The increased yield of lead and zinc in 1914 was due entirely to operations in the Miami field, as few of the mines in the Quapaw and Peoria districts were operated. The output of lead concentrates from these districts decreased about 100 tons, and the shipments of zinc concentrates of all classes declined from 1170 tons in 1913 to 154 tons in 1914.

The shipments of galena concentrates from the Miami district increased from 7710 tons in 1913 to 9401 tons in 1914, and the shipments of sphalerite from 23,018 tons to 28,219 tons. A considerable part of the 1914 yield was derived from mines southeast and northeast of the mines first developed in the camp. Several new concentrating plants were in operation and others are being erected. Notwithstanding the low prices of lead and zinc, ore-development work and prospecting were more active than in any other part of the Central States and conditions are favorable for an increased mine output in 1915.

PRODUCTION OF LEAD AND ZINC IN OKLAHOMA IN 1914, BY DISTRICTS
Short Tons

District.	Ores.						Metal Content.[a]			
	Lead Concentrates (Galena).		Zinc Concentrates.				Lead.		Zinc.	
	Quantity.	Value.	Sphalerite.		Carbonate and Silicate.		Quantity.	Value.	Quantity.	Value.
			Quantity.	Value.	Quantity.	Value.				
Ottawa County:										
Miami	9,401	$443,493	28,219	$921,647	.....	.....	7,555	$589,290	13,915	$1,419,330
Peoria	.....	.....	.....	.....	6	$100	.....	.....	2	204
Quapaw	1	50	146	5,091	2	40	1	78	75	7,650
State total:										
1914	9,402	443,543	28,365	926,738	8	140	7,556	589,368	13,992	1,427,184
1913	7,810	403,097	24,103	766,392	67	1,340	6,228	548,064	11,664	1,306,368
1912	4,257	231,678	12,129	494,379	92	2,550	3,388	304,920	5,769	796,122

a In calculating the metal content of the ores for assays allowance has been made for smelting losses in the case of zinc but not in the case of lead. In comparing the values of ore and metal it should be borne in mind that the value given for the ore is that actually received by the producer, whereas the value of the metal is calculated from the average daily quotations at New York and St. Louis.

Tennessee.—The output of spelter credited to Tennessee for 1914 is 6122 tons, a large increase over the figure of 2635 tons for 1913. Practically all of this came from the region northeast of Knoxville, the principal producers being the Grasselli Chemical Co., at New Market, and the American Zinc Co. of Tenn., at Mascot. The former produces smithson-

ite, while the latter is working blende ore with about 3½ per cent. zinc content, its mill having a capacity of about 1000 tons a day. At Embreeville, Washington County, some calamine is being obtained by hand picking at the old iron mines. On the whole the prospects look good for Tennessee to assume an important place as a zinc producer.

Texas.—Only 156 tons of spelter was credited for 1914, against 303 tons in 1913. The Sierra Blanco district produced most of this.

Utah.[1]—Zinc ores were mined at Tintic and Park City. The output from Tintic decreased, ore of this character being mined chiefly by lessees, who shipped 200 tons a month. The Daly-Judge was the principal producer at Park City. The tonnage of both zinc and lead ores produced by this company was the same as in 1913. The output of zinc in the form of concentrates was slightly less, but the grade was better, averaging above 40 per cent. No zinc middlings were made. Lessees working tailings plants made occasional shipments. No zinc ores or concentrates were produced by the Daly West. The Hidden Treasure mine, near Stockton, shipped two or three cars of zinc ore monthly. The Huff electrostatic plant of the United States company treated 40 tons of zinc middlings daily from its Bingham and custom ores.

District.	Ore.					
	Zinc Concentrates.				Zinc.	
	Sphalerite.		Carbonate.		Quantity. (a)	Value.
	Quantity.	Value.	Quantity.	Value.		
Benton	45,869	$764,631	.....	.....	12,606	$1,285,812
Cuba City	2,264	39,676	.....	.....	609	62,118
Dodgeville	705	13,609	.....	.....	231	23,562
Hazel Green	25,547	438,112	.....	.....	6,935	707,370
Highland	276	7,598	2,118	$29,689	609	62,118
Linden	6,470	120,373	.....	.....	1,947	198,594
Livingston	16,347	274,503	.....	.....	4,042	412,284
Mifflin	6,915	171,993	.....	.....	2,560	261,120
Mineral Point	.....	.....	614	7,694	128	13,056
Montfort	1,031	28,958	.....	.....	382	38,964
Platteville	2,665	54,037	55	650	891	90,882
Shullsburg	446	10,636	.....	.....	173	17,646
State total:						
1914	108,535	1,924,126	2,787	38,033	31,113	3,173,526
1913	95,540	2,053,341	3,123	30,769	30,110	3,372,320
1912	102,617	2,908,892	4,370	72,800	33,050	4,560,900
1911	93,963	1,929,123	5,035	74,143	29,720	3,388,080
1910	89,232	1,750,574	5,269	69,588	25,927	2,800,116
1909	65,421	1,505,752	5,130	63,603	23,152	2,500,416
1908	48,155	998,734	3,206	36,579	18,206	1,711,364
1907	47,251	997,127	3,065	40,422	18,490	2,181,730

(a) In calculating the metal content of the ores from assays allowance has been made for smelting and concentration losses in the case of zinc but not in the case of lead. In comparing the values of ore and metal it should be borne in mind that the value given for the ore is that actually received by the producer and that the value of the metal is calculated from the average daily quotations at New York and St. Louis.

[1] E. R. Zalinski, *Eng. Min. Jour.*

Virginia.—In the report of the U. S. Geological Survey, Virginia is credited with but 20 tons of spelter, against 116 tons for 1913. This decrease is probably due to the manufacture of more zinc oxide.

Wisconsin.—The preceding table, prepared by J. P. Dunlop, of the U. S. Geological Survey, gives the production of zinc in Wisconsin in 1914, in short tons.

The Benton district was again the largest producer of zinc concentrates, followed by Hazel Green and Livingston. All three districts produced more ore in 1914 than in 1913. A total of 46 mills and five roasters were in operation during the year. Eight new and re-assembled mills were added, namely, the Champion and Penna-Benton at Benton, the Kistler and West Hill at Platteville, the Coker No. 2 and Biddick at Mifflin, the Lawrence, Hazel Green, and the North Unity at Galena. The Kittoe at Benton, and the Thompson at New Diggings were in course of construction at the end of the year. The larger companies have done much prospecting and development work, and several good properties have been opened up.

Zinc Mining in Foreign Countries

Australia.—The production of spelter is practically confined to the Broken Hill district of New South Wales, where zinc blende forms one of the chief constituents in the enormous deposits of sulphide ores. The annual output of zinc concentrate at Broken Hill is 525,000 tons, containing 45 per cent. zinc. Previous to the outbreak of the European war most of this went to Belgium and Germany to be made into spelter, but now that these markets are closed to it, the mining industry of the district has been experiencing decidedly hard times. The following extract from a review of the situation at Broken Hill is from a report made by the chairman of the Sulphide Corporation:

"For generations Germany has cultivated and almost monopolized the industry of zinc distillation; the majority of the works which treat Australian zinc concentrates are situated in Germany, and the sudden closing of the German market for this class of material was an almost paralyzing blow to Broken Hill. We, perhaps, are in a slightly better position at the present time than some of our neighbors, because we have the works of the Central Zinc Co., in England, by means of which we have still an outlet for some portion of our production, but this portion is not very large. During the last 2 years we have produced 131,316 tons of zinc concentrates, and of these 19,633 tons has been treated at the works of the Central Zinc Co., while 116,296 tons has been sold at Broken Hill to Beer, Sondheimer & Co., of Frankfurt, under contracts

which have been running for many years. These contracts were, of course, brought to an abrupt stop at the beginning of August. The expansion of the Central Zinc Co.'s works, owing to the great difficulty in finding in England an adequate supply of skilled labor, can only be gradually carried out.

"We realized, however, that it was our duty, if possible, to continue work also at Broken Hill, where a complete stoppage of operations would have inflicted very severe hardship and distress upon the large mining population, and especially upon those who were married and had made their permanent home at Broken Hill. We therefore tentatively resumed work at the end of August, and during September, October, and November we continued to work the mine and mills alternate weeks, stacking the zinc concentrates produced and sending the lead concentrates to be smelted at Cockle Creek into lead bullion for shipment to our English contractors. So far as we can judge, we have been able while doing this to avoid loss and, thanks to a favorable lead market, to make some profit, so at the beginning of December we decided to increase our scale of operations at Broken Hill and to work the mine full time, at least so long as the lead market may warrant our doing so. We hope, therefore, that we shall now be able to make profits on a somewhat larger scale and as we are still without any substantial outlet for our zinc concentrates, we have established a plant which enables us, whenever we find it necessary to do so, to dump the residues from our lead mill for future use, without passing them into the zinc mill and incurring the expense of converting them into zinc concentrates."

Canada.—Considerable attention was given during the year to the production of zinc in British Columbia, and to the solving of the metallurgical problems presented by the complex ores of the region. With the increased demands for zinc caused by interruption of the normal supply by the war, the industry will undoubtedly be stimulated.

Japan.—The Omuta smelters are to be increased by another 10 furnaces, which will bring their total capacity to about 14,000 tons per year.

The production of spelter in Japan in 1914 was 4750 metric tons, of which the Mitsui Ohmuta works produced 2950, and the Osaka works 1800. At the present time the Mitsui Ohmuta smelting works is producing about 400 tons of spelter per month and the Osaka works about 200 tons per month. The Japanese production of zinc ore is estimated at about 35,000 tons. The importation of zinc, both in the form of spelter and sheet zinc, was 5800 tons for 1914, compared with 10,900 tons in 1913.

PRODUCTION OF ZINC IN EUROPE AND AMERICA (a)
(In metric tons)

Year.	Austria.	Belgium.	France.	Germany.	Holland.	Italy.	Russia.	Spain.	United Kingdom.	United States.	Totals.
1898..	7,302	119,067	37,155	154,867	6,700	250	5,664	6,031	28,387	103,514	468,937
1899..	7,192	122,843	39,274	153,155	6,235	251	6,331	6,184	32,322	117,644	491,431
1900..	6,742	119,315	36,305	155,799	6,845	547	5,963	5,611	30,207	111,794	479,128
1901..	7,558	127,170	37,600	166,283	7,855	511	6,090	5,354	29,877	127,751	516,049
1902..	8,309	124,780	36,300	174,927	9,910	485	8,280	5,569	40,244	143,552	552,356
1903..	8,949	131,740	37,416	182,548	11,515	126	9,901	5,134	44,110	143,792	575,231
1904..	9,159	137,323	41,600	193,058	12,895	189	10,607	5,887	46,218	164,921	621,857
1905..	9,204	142,555	43,200	198,208	13,550	5	7,520	6,184	50,125	183,014	653,565
1906..	10,711	148,035	46,536	205,691	14,650	69	9,610	6,209	52,587	204,548	698,646
1907..	11,208	154,492	(c)49,733	208,195	14,990	88	10,409	(c)6,000	55,595	226,398	737,108
1908..	12,770	161,940	47,880	216,490	17,257	(d)100	9,960	6,357	54,473	190,933	718,160
1909..	12,638	167,100	(c)49,718	219,766	19,548	(b)	7,949	(c)6,400	59,350	241,730	784,199
1910(f)	13,305	181,745	(c)51,527	227,754	20,975	(b)	8,128	(c)6,604	(e)63,587	251,348	824,973
1911..	15,766	198,230	57,110	235,776	22,734	(b)	9,652	6,333	(e)67,907	268,378	881,886
1912..	19,096	205,940	65,565	271,064	23,932	(b)	11,176	6,500	57,231	316,368	976,872
1913(f)	20,000	198,000	70,000	285,000	24,000	(b)	9,000	(g)	59,000	323,200	996,200

(a) From the official statistics of the various Governments except 1906 to 1911 inclusive, for which years the figures reported to Henry R. Merton & Co. have been used where the official statistics were unavailable. In addition to the production reported in this table, Australia produced 286 long tons in 1903, 299 in 1904, 544 in 1905, 1008 in 1906, 980 in 1907, and 1086 in 1908. (b) Included in Austria. (c) An approximate separation of the total which is reported for "France and Spain." (d) Estimated. (e) Includes 508 and 1000 tons from Australia. (f) *Eng. Min. Jour.* (g) Shown with France. Norway also credited with 8000 tons not shown here.

Mexico.—The unfortunate political conditions prevailing in Mexico have prevented producers from taking advantage of the somewhat more favorable import duties on ores entering the United States. During the first 8 months about 200 tons of zinc content and for the last 4 months about 1600 tons of zinc content were imported, the amount constantly increasing. During the year the mining industry has been almost paralyzed, and figures of production are not obtainable with any accuracy.

Poland.—The British Consul at Warsaw reports that the output of zinc ore shows no increase for the last 7 years. The three mines in the government of Kielce turn out on the average 65,074 tons of zinc ore per annum, and the average production of zinc amounts to 9185 long tons.

Russia.—Conditions for the development of a great zinc industry are not very favorable, due partly to the refractory pyritic ores and the excessive cost of transportation. Oxidized zinc ores are mined in Poland near the German frontier and in the East Siberian coast districts.

Silesia.—The zinc industry previous to the war was in a rather unsatisfactory condition, due mainly to the difficulty of disposing of sulphuric acid to advantage on account of high freight rates. Since the war began, production has been seriously interfered with.

South Africa.—A modern concentration plant was installed at the Blane-Witkop mine in the Marico district.

China (By T. T. Read). In southwestern China there are many zinc deposits, and there has been for many years a considerable spelter production by native methods, chiefly from Kweichow province, though

no records are available for estimating, the amount. The largest producer of zinc ore is the Shui-kou-shan mine which was described in the *Mining and Scientific Press* of June 12, 1915. This produced 22,875 tons of zinc concentrate in 1914; the coarse concentrate containing 53.4 per cent. zinc and the fine concentrate 30–35 per cent. zinc. This is now sold to Carlowitz & Co. for shipment to Europe, but the company is considering the desirability of erecting a smelter of its own.

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Metallurgy of Zinc in 1914

By W. R. Ingalls

The art of zinc smelting is one involving a multiplicity of details, careful attention to which is necessary in order to secure good metallurgical results. Progress in this branch of metallurgy therefore rarely occurs through the introduction of any radical innovation, but rather through improvements in minor details.

Thus American smelters have been devoting a good deal of time and expense to the manufacture of a retort of more tensile strength and more

durability than has heretofore been made in this country. As a rule, the "hard driving," *i.e.*, distillation at very high temperature, as practised in Germany and Belgium, is unknown in America. Distillation under that condition means higher extraction of zinc, other things remaining equal, one of the things that must remain equal being satisfactory retort life. Certain American smelters have been directing their attention to making retorts conforming essentially to those used in Germany. They have been handicapped somewhat by the American clays, which do not conform to the European, but the difference has been rectified artificially. The retorts made in this way by one important smelter show a much longer life, the retorts lasting until the shell, in numerous cases, is not over $\frac{3}{8}$ in. thick.

Considerable attention is also being given to the analysis of the reduction fuel, and the relation of the elements of its ash ingredients to the same elements in the ore, having in view a better blending of ore and reduction material. This, of course, is excellent sense.

It is attention to just such details as the above that makes or breaks the zinc smelter. At Hillsboro, where such thought and care have been exhibited, the extraction of zinc averaged about 2 per cent. higher in 1914 than in 1913.

Furnace Firing.—Experimental novelties in the firing of both roasting furnaces and distillation furnaces are the use of crude petroleum and coal dust. Crude-petroleum firing has indeed ceased to be a novelty. Coal-dust firing was tried at Collinsville, Ill., in connection with the roasting furnaces (Brown horseshoe) and the distillation furnaces, but the experiments were not developed to a conclusion. Nor were they at Cherryvale, Kan., where one of the distillation furnaces was fitted up for this purpose. The indications were regarded favorably at Cherryvale, the ability to produce the requisite temperature and the cheapness of this method of firing being regarded as settled, but the mechanical details remain to be worked out satisfactorily.

At Cherryvale several of the furnaces are regularly operated with oil-firing and with oil- and natural-gas-firing combined. The oil burners take low-pressure air, low-pressure oil and high-pressure steam. These burners, five in number, are introduced from the cellar into the rear of the combustion chamber.

In connection with the roasting furnaces the oil burners are also successful. They are introduced through the roof arch, being placed like the five of a pack of playing cards. The first two, set abreast, are each about 2 ft. from the side wall of the furnace. The next burner is 9 ft. back of the line of the first two. The two remaining burners are 9 ft. back of the middle one.

It is found at Cherryvale that in roasting about 125 gal. of oil per ton of crude ore is required, and in distillation about 250 gal. per ton of roasted ore. With oil costing 50 cts. per bbl., the use corresponding to those figures is reckoned as being equivalent to the use of gas at about 6 cts. per 1000 cu. ft.

Treatment of Residuum.—The method in use at Cherryvale, which has been mentioned in previous reviews, continues to give satisfactory results. All of the residuum is sifted over a screen with ⅝-in. apertures and over a 20-mesh screen. The oversize from the ⅝-in. screen goes back to the distillation furnaces, being high in zinc. The material between ⅝-in. size and 20-mesh goes to the steam boilers, where it is burned on perforated grates, undergrate blast being supplied by Connersville blowers. Some zinc oxide is recovered from the rear of the combustion chamber and is saved.

At the Bartlesville works of the Bartlesville Zinc Co., Archibald Jones is clinkering the residuum by burning it in heaps, the prime purpose being to put it in good condition for the lead smelter, but incidentally some of the zinc is reduced, volatilized and collected as oxide in the outer part of the heap. Such portions are saved separately for reworking for zinc. The amount gained in that way is perhaps not yet very large, but Mr. Jones has by no means given up hopes of increasing it.

Charging and Discharging Machines.—The use of the Saeger charging machine is now a matter of regular practice at the works of the National Zinc Co., at Bartlesville, Okla. It is found that the quality of the work done by this machine is better than it is possible to do by hand, *i.e.*, the retort is much more satisfactorily charged. The operation of hand charging requires 3 hr. The machine does it in 1 hr. and enables 2000 lb. more of ore to be put in the furnace. In other words, the retorts are charged more densely.

It is found that the excessively fine flotation concentrates now coming to the zinc smelters are producing two difficulties in machine charging. One of these is the sticking of the very fine ore to the augers, necessitating frequent cleaning of them during the charging operation. The other is the tendency of the retorts to blow out with considerable force, sometimes only 20 min. after they are charged, thereby burning the men putting up the condensers. This, of course, is due to the difficulty of the gas to find egress through the minute interstices of this excessively fine charge; and increasing the density of the charge naturally increases this difficulty. Gas is developed in the charge, and, being unable to issue freely, acquires an increasing pressure from the heating until the pressure becomes sufficient to blow out more or less of the charge. Even before the days of the charging machine and the fine flotation concentrates, cases have

been known of a retort actually exploding when it had been charged very densely and had not been spiessed sufficiently often.

J. J. Simmonds, of Iola, Kan., patented a retort-discharging machine. This consists substantially of a truck carrying a series of bars, or plungers, with sprockets at each end of the bar over which travels an endless chain of scrapers. The machine is run up facing a tier of retorts, into which the scrapers are introduced and set in motion, the mechanical arrangement being very ingenious. After one tier of retorts has been cleaned, the scrapers are withdrawn, the machine is moved ahead, and another tier is treated in the same way, the discharging of the retorts being thus done tier by tier. This apparatus was developed at the works of the Laharpe Smelting Co. After that plant became idle the machine was put in operation at the No. 3 plant of the Prime Western Spelter Co., at Iola, and was operated there for 3 months for demonstrating purposes. Mr. Simmonds, the inventor, has informed me that the average time required to discharge a tier, or vertical row of retorts, is about 45 sec., when the machine is once in position at the furnace and in motion, divided as follows: 5 sec. to move the scrapers to the mouth of the retort, 25 sec. to discharge the retort, 10 sec. to withdraw the scrapers, and 5 sec. to move the machine forward to the next position, *i.e.*, to attack the next tier of retorts. The scraper chains are sprayed with water, which keeps them cool. The apparatus is not only speedy, but also is reported to do good work and to be capable of handling a residue that is considerably fused. In the opinion of some distinguished zinc metallurgists this machine has solved the problem of mechanically discharging retort-residues. Arrangements are now being made to install the machine at three works.

Roasting Furnaces.—The new Sand Springs plant in Oklahoma was equipped with Cappeau furnaces, but most of the new zinc smelteries of the United States are built in the Eastern coal fields, are designed to make sulphuric acid and their builders stick to the mammoth Hegeler furnace, a construction capable of roasting about 50 tons of ore per day and costing about $75,000. The improvements in this furnace, since its introduction about 30 years ago, have been only in structural features and mechanical details.

The Spirlet, one of the popular new European furnaces, was introduced in the United States in 1914 by the Grasselli Chemical Co. This is a multiple-hearth turret-furnace, whereof the hearths themselves are revolved, projecting teeth from the bottom of one hearth rabbling the ore on the next hearth below. The furnace is ingeniously designed so that it may quickly be dismantled for repairs and it desulphurizes blende with very low fuel consumption, 10 per cent. or less.

Hydrometallurgical Process.—At any given time during the last 20 years it has been safe to assume that experiments with hydrometallurgical processes of zinc extraction are going on at three or four places, and 1914 was no exception. The work at Bully Hill, Calif., was checked, but only temporarily, the metallurgists of that company apparently thinking well of the results so far. Some plans regarded as promising are also being carried out by the Consolidated Mining & Smelting Co. at Trail, B. C. Both at Bully Hill and at Trail the idea is to sulphatize the zinc and electrolyze the solution. The Bunker Hill & Sullivan took over the Malm process, has tested it in a 50-ton plant at Kellogg, Idaho, and Mr. Bradley has pronounced it a success. In this process the zinc and lead of the ore are chlorinated, giving a chloride solution from which metallic lead is precipitated by means of metallic zinc. The zinc-chloride solution is then boiled down and molten zinc chloride is electrolyzed, giving chlorine and zinc, which go back to the process, except that the surplus zinc is ready for market as spelter. Some details of the process remain to be worked out, among others the handling of the chlorine gas, which always has been a troublesome feature in the processes of this class. In California some experimental work was done with the Reed process, making electrolytic zinc out of the bag-house fume from the Mammoth Copper Co.

Electric Smelting.—No additional news of technical nature has come from Trollhättan and Sarpsborg. A lawsuit over patents between the Trollhättan and the Ilen companies in Norway was decided in favor of the latter. Thierry is reported to be smelting in the Pyrenees zinc residues from the indigo-dyeing industry and to be making a commercial success of it. Krefting did experimental work in Norway, Cote & Pierron at Ugine, in Savoy, and Queneau in Belgium. The experimental work at Nelson, B. C., was discontinued, it being regarded as conclusively settled that an electric zinc-smelting furnace so small as 1 ton of daily capacity is a commercial impossibility, while the satisfactory development of a larger furnace was regarded as too doubtful to be undertaken at Nelson. Johnson did a lot of interesting work at Hartford, Conn., and organized a company that is going to build a commercial plant at Keokuk, Iowa, his plans including a 100-ton plant, the first 10-ton unit of which is now being designed.

PROGRESS IN ORE DRESSING AND COAL WASHING IN 1914

By Robert H. Richards and Charles E. Locke

General

In looking over the past year the almost universal interest in oil flotation stands out preëminently, and one is surprised to see the number of mills that have either installed oil flotation as part of their flow sheet, especially for improving the recovery from tailings and slimes, or are experimenting before finally deciding on the type of flotation apparatus that will be adopted. The increased recoveries due to the use of flotation are already amounting to very large sums when expressed in terms of dollars and cents.

After flotation the question of crushing machines, especially those machines which are used in the field of fine crushing, may perhaps be said to stand out next in importance. The extension of the use of pebble grinding for concentrating has been very marked.

At the Calumet and Hecla Mills at Lake Superior, a leading problem is the recovery of copper from the mill tailing. Two mills have been built for this purpose, one depending on Chile mills, classifier and Wilfley tables, the other depending on Hardinge mills, classifier and Wilfley tables. The grouping of the machines in the two mills is the same. In the mill using Chile mills, 1650 tons of sand goes to 48 Chile mills feeding 24 classifiers making sand and slime. There are 72 sand Wilfley tables and 48 slime Wilfley tables, and the middlings of all these go to 16 middling tables and from these the middling is returned to the same table.

A method of leaching for copper in the tailing sand is under investigation and nearly ready to install. The details about it are not yet made public officially, although statements have appeared that it is based on the use of ammonia and that 70 per cent. of the copper in these tailings will be recovered.

This problem of getting more copper from the sand is active in all the copper concentrating plants of Lake Superior.

In Montana the Anaconda Copper Mining Co. has improved the treatment of sands to the extent of reducing the per cent. of copper in the sand tailing from about 0.7 per cent. to about 0.45 per cent. copper by the use of efficient classification to prepare for feeding the Wilfley

tables. The company has reduced the content of copper in the slime 0.08 mm. to 0 mm. from 2.2 per cent. to 1.1 per cent. copper by the use of the convex 20-deck round table with a rough surface, run slowly. It has also brought the slime by flotation down to 0.18 per cent. in the experimental 50-ton plant. Grinding the mill tailings through 0.2 mm. and treating by flotation has lowered the copper in the tailing to 0.1 per cent. copper. The new 2000-ton lixiviation plant will treat the dump mill tailing that has accumulated to the amount of about 16 million tons. This material carries about 0.7 per cent. copper and will yield 85 to 90 per cent. of this value in the lixiviation treatment.

The latest word from Anaconda is that all crushing will go directly to 7 mm., that the sizes 7 mm. to 1.5 mm. will be treated on Hancock jigs, yielding concentrate and middling. The latter will be crushed by rolls to 1.5 mm. and all 1.5 to 0 mm. will go to Anaconda classifiers. The spigot will go to Wilfley tables with Butchart riffles and yield concentrate and middling. The middling will go to the tube mills with Dorr classifiers returning the sand coarser than 60 mesh to the tube mill, and the slime from the Anaconda classifier and the Dorr classifier will go to flotation or to round tables followed by flotation. It is expected that the present extraction of 78 per cent. will be raised to 91 per cent. by the new scheme and the mill tailings reduced to about 0.1 per cent. copper.

The mill of the Butte and Superior Copper Co., Ltd., at Butte, Mont., treats ore carrying galena and blende by jigs, classifier and tables, making galena concentrate, blende concentrate and blende middlings. The zinc middling is then concentrated by flotation, using the Hyde process, producing zinc concentrate and tailing.

Timber Butte Mill uses jigs, classifiers and tables, making galena concentrate, blende concentrate, and galena and blende middlings; the latter is reground and reconcentrated, making galena, blende and blende middlings. The middling is subjected to flotation, using Minerals Separation Co. process. The concentrate from flotation is again concentrated on Wilfley tables, yielding galena and blende concentrate.

The Butte and Duluth Co. works carbonate and silicate of copper in a siliceous gangue. By leaching with hot sulphuric acid a certain amount of ferric sulphate is formed which greatly increases efficiency. The leaching is done by five graduated Dorr classifiers in series, turning out clean washed tailings at one end and strong solution at the other. The precipitation with insoluble anode is made more efficient by stopping when the copper is half extracted and by placing the electrodes lengthwise instead of crosswise in the vats.

In the Cœur d'Alene region the Gold Hunter Mill jigs six sizes between 11 mm. and 20 mesh. The middlings crushed by rolls are jigged

on secondary jigs in four sizes between 5 mm. and 20 mesh. The 20 mesh to 0 is divided into three sizes by classifier and Callow cone, which go to Wilfley and Deister tables. The middlings from these join the middlings of the secondary jigs and go to the tube mill to 20 mesh screen, then drag classifier and two sizes hydraulic classifier to three sizes of Wilfley. The middlings from all the Wilfleys go to Wilfleys. The slime from drag classifier goes to Callow cones and Callow pneumatic flotation.

Federal Company's Morning Mill treats ore with galena, blende and pyrite and with siderite and quartz gangue. The jigging is as follows: Larger than 1 in. by Harz bull jig; 25 mm. to 12 mm. by Harz bull jig; 12 mm. to 5 mm. by Hancock jig; 5 mm. to 1 mm. by Hancock jig (from all the above the middlings are crushed by rolls and sent back, no tailings made); 1 mm. to 0 mm. by 1-spigot classifier, spigot to fine Hancock jig, middling of which is recrushed by Hardinge mill and sent back and no tailings made; overflow to Esperanza classifier. From this the sand goes to a 4-spigot classifier and Wilfley tables, middlings of which are recrushed by Hardinge mill and sent back, and tailing sent to McQuisten tube flotation. The overflow of last classifier goes to settling tanks yielding spigots to Deister tables and vanners; the tailings from all these to Callow flotation.

The National Mill works down through tables to Callow flotation. About 55 per cent. of concentrates is made on flotation machine, balance on tables, no jigs in mill.

The Greenhill Cleveland Mill treats argentiferous ore containing galena, blende, siderite and quartz. Over 15 mm. is jigged on bull jigs and 15 to 10 mm. the same; middling from both is crushed by rolls to 10 mm. and sent back; tailings of both is waste; 10 to 6 mm. is jigged; middlings to rolls to 6 mm. and back; tailings waste; 6 to 3 mm. is jigged; middlings to rolls; tailings waste; 3 to 2 mm. is jigged; middlings to Hardinge mills; tailings waste; 2 mm. to 0 to 3-compartment classifier. All three spigot products jigged; middlings to Hardinge; tailings waste. Overflow of classifier to Esperanza classifier, sand to 4-compartment classifier and Wilfley tables. Overflow of Esperanza to Callow tanks and vanners. Tailings of vanners to Callow flotation. The efficiency for silver is reported to be 81.4 per cent.; the efficiency for lead is reported to be 86.6 per cent.

Hercules Mill treats argentiferous ore containing galena, blende, pyrite, siderite; 50 to 20 mm. jigged gives concentrate and middling reground in coarse rolls; 20 to 12 mm. jigged gives tailings waste, middling reground by rolls; 12 mm. to 4 mesh, to Hancock jig yielding tailing waste, and middling reground; 4 mesh to 8 mesh to Franz jig giving tailing waste

and middling reground; 8 mesh to 20 mesh to Franz jig giving tailing waste and middling reground; 20 mesh to 0 goes to slime house containing classifiers with 4 spigots to tables and overflow to Callow cones. Wilfley tables, Card tables, Franz tables and vanners used. The feed to the flotation nearly all passes through 20 mesh. The Wyman flotation process is used at the mill.

At Grass Valley, California, the North Star Mining Co. has worked up the stamping, amalgamating and cyaniding with remarkable success. Stamping and plate amalgamation are followed by the Dodd circular buddle without any preliminary classification. The concentrate put through tube mills goes back and mixes with the tailing of the Dodd buddles; the two are then separated into sand and slime; the sand is percolated, the slime agitated with cyanide. The extraction reported is 98 to 98.5 per cent. A new gravity stamp cam giving accelerated velocity is used in this mill.

The great dredge at Folsom, California, has buckets of 15 cu. ft. capacity, 8000 cu. yd. a day, 400 cu. yd. an hr., uses 1122 hp. The dredging cost is about 7 cts. a cu. yd. The rock breakers for road material at Folsom take the boulders from the dredge. The material is screened and broken down to the various sizes needed for road making and for concrete; 2000 tons a day are broken. At Folsom the land has been leveled off and eucalyptus trees planted. They have reached 20 or more ft. high and look healthy and strong.

At Idaho Springs, Colorado, the Newton Mill is trying out the new Wilfley slimer on its slimes.

At McGill, Nevada, the mill of the Nevada Consolidated Copper Co. brings the porphyry copper ore down by graded crushing to 2 mm. in size; classifiers then divide the pulp into feed for Wilfley tables and vanners. Tailings of the Wilfley tables treating the coarser product are reground by Chile or Huntington mills, or regrinding rolls, and go to secondary classifiers followed by Wilfleys and vanners. The overflow of the primary and secondary classifiers is being experimented on by flotation processes. The underflow slimes of the water-recovery ponds, fed by Callow tank overflows and slimes from the finer tailings, are also being experimented on by flotation methods. The mill treats about 10,000 tons a day when running at full capacity.

Crushing and Grinding

Rock Breakers.—Comparisons of gyratory and jaw breakers and of sectional and solid frames have been made in the form of graphical curves by C. T. Hutchinson.[1] It is commonly conceded that a solid frame

[1] *Min. Sci. Press*, 98, 222 (1914).

breaker is heavier and more difficult to transport, while a sectional breaker is mechanically more difficult to construct so as to maintain its rigidity, especially in the larger sizes. The curves showing relation of factory cost and *area* of feed opening indicate that the gyratory breaker is the cheapest down to the No. 3 size with two feed openings each 8 by 30 in. The solid frame jaw breaker is cheaper than the sectional on large sizes, but on small sizes the reverse is true. Curves showing the relation of factory cost and *width* of feed opening indicate that the gyratory is the most expensive in all sizes, and that the sectional jaw breaker is cheaper than the solid on small sizes but more expensive on large sizes.

For fine crushing the Symons disc crusher has been increasing in favor. A new design treats material at 1½ or 2 in. and crushes it as fine as $\frac{3}{32}$ in. The Symons vertical breakers are also being installed in many mills for the regular coarse or preliminary breaking.

Rolls.—Experience at Miami has shown that with hard ore a mechanism designed to give a fleeting or endwise motion to a pair of rolls in order to prevent corrugations will not stand up if the cycle of movement is completed in 1 min., but that by reducing the speed of the end movement so that the cycle is completed in 30 min. a mechanism may be used which gives no trouble.[1]

The development of the use of rolled steel for shells and tires in rolls and Chile mills has been discussed by J. C. H. Ferguson.[2] The line of development has been through cast iron, chilled iron, cast steel and rolled steel. The material for rolled steel averages 0.65 to 0.80 per cent. carbon, not over 0.05 phosphorus and 0.04 sulphur, 0.60 to 0.85 manganese, and 0.15 to 0.30 per cent. silicon. The method of manufacture is much the same as for locomotive tires, that is, the steel ingots are cast in cylindrical form and the top pipe sawed off and discarded; the remainder is cut into short cylinders or billets by saws, usually cold but sometimes hot; the billets are reheated and punched and worked down by hammers or hydraulic presses into a rough ring which goes to rolls for final shaping. At present, rolls are not powerful enough to handle a metal ring thicker than 5 in. or more than 16 in. width of face. The largest sized shell it is possible to make is at present 8 to 10 in. wide, 108 in. outside diam. by 3 in. thick, or 10 to 16 in. wide, 68 in. outside diam. by 3 in. thick. The inner side of the finished ring may be left rough for fastening to the core by wooden wedges, or it may be machined to various forms such as straight bore, single taper bore, double taper bore, tapered bores recessed for draw bolts, depending on the method

[1] *Eng. Min. Jour.*, **97**, 518 (1914).
[2] *Bull. Amer. Inst. Min. Eng.*, **93**, p. 2333, Sept., 1914; *Min. Sci. Press*, **109**, 809 (1914).

which is to be used for fastening the shell to its cores. The outer surface of the shell is not touched, since the rolling operation forms a hard skin which lengthens the life of the shell appreciably.

Some complete data of examples of wear on this rolled-steel material are given in the original article, showing ranges of steel consumed per ton crushed from 0.093 to 0.94 lb. for Chile mills and from 0.0159 to 0.210 lb. for Cornish rolls, depending in all cases on the character and size of the material crushed.

Rigid rolls which were formerly used at the Miami Mill have been replaced by 42 by 16-in. heavy type rolls, so that the crushing system now consists of two gyratory breakers crushing to 3 in., two pairs of 56 by 20-in. rolls delivering to ¾-in. trommel, two pairs of 42 by 16-in. rolls crushing oversize of ¾-in. trommel, and six pairs of 42 by 16-in. rolls crushing through ¼-in. trommel, and 18 Hardinge mills 8 ft. by 22 in. crushing through 20-mesh Callow screens. This rearrangement makes a saving in pebble consumption of 1.44 lb. or 1.84 cts. per ton crushed.[1]

Steam Stamps.—The question of the continued use of the gravity stamp under the new régime for coarse crushing gold ores without amalgamation has led to a consideration of the steam stamp for this work.[2]

The large steam stamp has held the field in the Lake Superior native copper mills because no other machine could liberate the native copper nuggets, leaves and flakes in so satisfactory a manner. Its work is to take feed as coarse as 4 in. and crush through a ⅝-in. screen, treating as much as 600 tons in 24 hr. It has a roomy mortar and special devices for avoiding attrition of metallic copper. The cost for wearing parts is low. It is only fairly economical in the use of steam, even when of the compound type and exhausting to a steam turbine.

At first glance the use of one steam stamp instead of many gravity stamps with their greater cost of installation and their requirement of greater space and more attention would appear to be an advantage which could not be offset. Further, there is no question regarding the ability of steam stamps to satisfactorily crush as fine as ⅛ in., although at decreased capacity and perhaps also at decreased efficiency. However, the steam stamp is limited to the use of steam power, and although no exact figures of comparison are available, it appears from the information at hand that steam stamps cannot be as efficient in the use of steam as gravity stamps driven by an efficient steam engine. Cheap hydroelectric power can be applied to a gravity stamp mill, but would be absolutely useless for steam stamps. A further cause of inefficiency in steam stamps is that a thick bed of ore must at all times be kept on the

[1] J. P. Channing, *Eng. Min. Jour.*, **97**, 59 (1914).
[2] A. Del Mar, *Min. Sci. Press*, **109**, 511, 513 (1914).

die, as otherwise the shoe striking through to the die with the enormous blow would tend to cause breakage either above or below. While the compactness of one unit has been cited as an advantage, still it might under certain conditions become a disadvantage where a breakdown occurred and required the shutting down of the whole mill. With gravity stamps, one stamp out of commission means only a slight loss of mill capacity.

From the foregoing it does not seem probable that steam stamps will replace gravity stamps for coarse crushing as satisfactorily as some other machine, for example, rolls.

Gravity Stamps.—Good practical ideas on stamps have been published by W. H. Storms.[1] In setting wooden mortar blocks on bed rock he recommends a 14- to 18-in. layer of concrete on the bed rock topped off with a layer of 3 parts sand to 1 of cement. By the use of suitable forms a ridge of concrete may be made, thus forming a pocket or socket of exactly the same size as the chamfered bottom end of the mortar block. The mortar block itself is best made of 2 by 12-in. planks on end spiked together with their long faces parallel to the front of the mortar, and is lowered into its socket which is sprinkled with a 1-in. layer of sand to receive it. The pit, about 30 in. wide both in front and back of the mortar block, is filled with clean sand run in with water after the block is in place.

Where no bed rock occurs within a depth of 16 or 18 ft., a solid concrete mortar block is built up with a broad base. The bottom part consists of a concrete mixture of 4 parts rock crushed through 2½-in. ring, 2 parts sand and 1 part cement, all rammed in. The top 5 or 6 in. should be richer in cement. In case bed rock is available the concrete mortar block may be narrower at the foundation.

For stamp frames four battery posts with center pulley for ten stamps decrease vibration and breakage of cam shafts over three posts.

Needle-punched tin screens are preferable except in special cases. Mortar linings are now in general use and mortars are made narrow for rapid discharge, 2½ in. space from the top back edge of the die back to the lining and 5½ in. from the front edge to the plane of the screen. Back linings slope 75° to 77°.

Other subjects discussed are height of discharge, cams, stamps, temperature of water, plates and ore bins.

The fine-crushing practice on silver ores at Cobalt, Ontario, is a good example of the effect of conditions on the choice of apparatus. It is significant that nearly 45 per cent. of the low-grade ore concentrated on tables in that camp is crushed by stamps alone, and that nearly 83 per

[1] *Met. Chem. Eng.*, **12**, 225 (1914).

cent. of the low-grade ore is crushed, in part at least, by stamps which are supplemented by pebble mills.[1] There are several reasons for this: (1) The ore is hard and tough. (2) The mills are mostly small, not over 100 tons daily capacity. (3) The life of the district is anticipated to be short. (4) Stamps have a wide crushing range and are simple and reliable. On an ore containing around 16 oz. silver per ton the stamp product can be concentrated so that the tailings will assay only 3 or 4 oz., except that the slimes will run 6 or 8 oz. To effect greater recovery the tailings would have to be crushed to fine slime. (5) If rolls were used, stage crushing would be required and the simplicity of the mill would be lost.

In the use of heavy gravity stamps American practice still remains conservative. The Nipissing 40-stamp mill at Cobalt perhaps represents the present ideas of engineers on this point. In this the stamps weigh 1500 lb.[2] The mortar block foundation, 81 ft. long by 6 ft. wide on top, contains 846 cu. yd. of concrete. Mortar anchor bolts are set on an incline for easy removal. Battery posts are 12 by 26 in. and 24 by 26 in., set in cast-iron shoes, rubber ¼ in. thick being placed between the shoes and concrete. The mortars are rapid discharge, weighing 12,410 lb. including steel liners, and are separated from the concrete foundation by ¼-in. thickness of rubber.

The stamps are fastened five on a 7-in. cam shaft by Blanton fluted cams. The order of drop is 1, 3, 5, 2, 4 with a set height of 8 in. at 96 drops per min. The height of discharge is 1 in. The stamp weight is made up of stem 681 lb., tappet 190 lb., head 412 lb., and shoe 254 lb.; total 1537 lb. Each unit of ten stamps is driven by a 40-h.p. electric motor through a countershaft. Screens are double crimped wire cloth of cast high carbon crucible steel and show practically no wear after 3 months' use. Chilled-iron mortar lining 1 in. thick lasts 30 days, while manganese steel lasts 165 days. Forged chrome steel shoes last 105 days crushing 703.5 tons, while dies last 130 days or 871 tons. Using 8-mesh screens on one-half the stamps and 4-mesh on the other half (0.077-in. and 0.178-in. holes respectively), the capacity is 5.7 tons per stamp per 24 hr. Using 3-mesh and 2-mesh (0.261-in. and 0.408-in. holes), the duty is 6.7 tons. Under the latter conditions 25.1 per cent. of the pulp is coarser than 8 mesh, 53.62 per cent. is between 8 and 100 mesh, 3.58 per cent. is between 100 and 200 mesh and 16.71 per cent. is finer than 200 mesh.

Standard California crushing practice has not been followed in the new Plymouth Mill.[3] No grizzly is used, the ore all passing through

[1] F. D. Reid, *Can. Min. Inst.*, **17**, 50 (1914).
[2] J. Johnston, *Bull. Amer. Inst. Min. Eng.*, **85**, p. 107, Jan., 1914.
[3] G. Caetani, *Min. Sci. Press*, **109**, 670 (1914).

a No. 5 Gates gyratory breaker running at about half its rated speed. The ore is soft and has considerable fines, so that the breaker running under choked feed acts as a feeder to the conveyor belt taking the crushed ore to bins. There are thirty 1250-lb. stamps with 4-mesh screens and the duty per stamp is 11 to 14 tons per 24 hr. These are followed by two 8-ft. by 22-in. Hardinge mills, making a product which will practically all pass through 40 mesh. The pulp after passing over amalgamated plates is classified and concentrated on two Wilfley tables and 30 Isbell vanners.

Caetani expresses the opinion that ball mills may be better than gravity stamps for crushing friable ores to ¼-in. size. Including bins, foundations, etc., a ball mill plant will not cost over one-third of a stamp mill of equal capacity. The wear of metal will probably be a little more for ball mills but the power consumption should be less.

Interesting comparisons of three crushing methods will be obtainable when the new mills at Juneau, Alaska, are in full operation, crushing low-grade gold ore containing 1 to 2 per cent. of concentrates. There are three methods which will be in use.[1]

The present practice in the Treadwell mills is to crush in breakers and stamp to 25 mesh, using 1250-lb. stamps crushing 4.8 tons per stamp per 24 hr. The stamp pulp flows over amalgamated plates and is concentrated on vanners, the concentrates being ground in tube mills and cyanided.

The Alaska Juneau mill is to crush 600 to 800 tons per 24 hr. per mill unit, using a No. 6 D Gates breaker followed by smaller Gates to 2-in. size. A 2-in. grizzly precedes the first Gates and a 2-in. trommel precedes the second. The ore is screened at 7/16 in. and the oversize after crushing in forty 1260-lb. stamps joins the undersize and is concentrated on roughing tables. Tailings are waste, while concentrates are to be reground in Hardinge tube mills or 6-ft. Chile mills and run over amalgamated plates and then concentrated on Wilfley tables, yielding galena to smelter, pyrite concentrates to cyanide plant and tailings to waste. The method of treating slimes is undecided as yet.

The Gastineau mill of the Alaska Gold Co. will have a capacity of 6000 to 8000 tons in 24 hr. The ore is first crushed underground by two jaw breakers 36 by 42 in., followed by four gyratory breakers crushing to 3 in. In the mill the ore goes through two 72 by 20-in. rolls followed by ten 54 by 20-in. rolls delivering a product through 12 mesh. This is concentrated on roughing tables, making high grade and low grade. The latter is reground in 6 by 8-ft. tube mills and joins the high grade, going to a second set of tables making galena to smelter, pyrite concen-

[1] F. Close, *Min. Mag.*, **11**, 121 (1914).

trates to be ground in tube mills and amalgamated or cyanided, and tailings to waste. This is claimed to be the first instance of the use of rolls in the place of stamps in gold milling.

It is generally conceded that Nissen stamps with single stamp mortars have higher capacity than California gravity stamps. This was also shown by the results of tests at the City Deep mill in South Africa.[1] A recent test on Cornish tin ore at Tincroft shows, however, that by the use of a narrow rapid discharge mortar and by the exercise of care in keeping the stamps dropping squarely on firmly set dies by means of strong iron guides, the California stamp may even excel the Nissen. The following tables give the results of the tests:[2]

RESULTS OF TEST FROM JUNE 18 TO JULY 16, 1914

	5 California Stamps.	2 Nissen Stamps.
Tons crushed	854.44	562.03
Total days run	23.89	24.61
Tons per day	35.765	22.837
Stamp duty, tons per day	7.153	11.418
Total h.p. consumed	16.231	12.176
H.p. per ton crushed per hr.	10.959	12.796
Tons per h.p. per day	2.19	1.875
Cost of power per ton in cents	10.638	12.42

SIZING TESTS OF PRODUCTS

	California, Per Cent.	Nissen, Per Cent.
On 20 mesh	13.37	15.62
Through 20 on 30 mesh	15.61	15.97
Through 30 on 40 mesh	9.21	8.30
Through 40 on 60 mesh	12.08	11.88
Through 60 on 100 mesh	10.55	9.94
Through 100 on 150 mesh	9.43	8.13
Through 150 on 200 mesh	3.03	3.20
Through 200 mesh	26.40	26.63
	99.68	99.68

The two Nissen stamps weighed 2000 lb. each while the five California stamps weighed 1250 lb. each. The screens used in both cases were 10-mesh standard.

Tests of two Nissen stamps against ten California stamps at the South Crofty Mill show results in favor of the Nissen, but it is presumable that in these tests no special measures were taken to obtain a quick discharge from the California stamps.[3]

Newer gold mills have mortars with removable front, *i.e.*, the front is a separate piece of steel and is bolted to a mortar casting and when removed makes the interior more readily accessible. In a design made

[1] MINERAL INDUSTRY, **20**, 359.
[2] E. S. King, *Min. Mag.*, **11**, 378 (1914).
[3] *So. Afr. Min. Jour.*, Nov. 8, 1913; *Met. Chem. Eng.*, **12**, 198 (1914).

by the Denver Engineering Works both front and back are straight, and the base has an opening cast in it from back to front to serve for by-passing the undersize of a screen which may be installed behind the mortar to remove any material from the feed which is already sufficiently fine.

Good results have been reported by C. L. Proebstel from setting stamp dies in concrete.[1] The dies are first placed on an ordinary cushion of sand and then the space around the dies up to the underside of the chuck block is filled with a concrete of 40 per cent. Portland cement and 60 per cent. clean quartz sand. This is tamped in and allowed to set for several days. The concrete wears away as the die wears, forming a cup-shaped depression which tends to throw the pulp back on the die and help amalgamation. There is no difficulty in removing worn-out dies. Other advantages claimed are: (1) It is not necessary to remove dies at time of clean-up. (2) The amount of coarse sand at clean-up is reduced. (3) There is no danger of the dies bouncing or moving.

A modification of the usual involute form of stamp cam has been designed by A. B. Foote and is reported to be running satisfactorily in the North Star mill at Grass Valley, California.[2]

This cam has a flatter curve both at the hub and at the tip, the result being that the stamp picks up its motion more gradually and is constantly accelerated, so that it leaves the cam at a higher velocity than in the case of the involute cam. In other words, the stamp receives harmonic motion from the point of zero to maximum velocity where its speed is so great that finger bars may be inserted without the use of a cam stick. The advantage is that there is no shock when the stamp starts to lift; the disadvantages are that the cam face is not parallel to tappet in every position of contact and that the curve will give the ideal harmonic motion only when the stamp is set for exact drop for which the cam was designed, but the improved cam will not be as bad as the involute until the drop is reduced one-half. The lack of parallelism has not been found to lead to any bad results.

Grinding Pans.—In the continued discussion[3] of these machines some further details and explanations have been brought out which were not given last year (see MINERAL INDUSTRY, **22**, 818).

A study has been made of a 5-ft. grinding pan at the Beck Mill, Atlantic City, Wyoming.[4] This pan treats the product of four Nissen stamps crushing 26 tons per 24 hr. through 16-mesh screens. At the outset the pan capacity was very low, owing to the fact that the die had no

[1] *Min. Sci. Press*, **108**, 387 (1914).
[2] *Bull. Amer. Inst. Min. Eng.*, **96**, 2765, Dec., 1914; *Min. Sci. Press*, **109**, 955 (1914); *Eng. Min. Jour.*, **98**, 1046 (1914); *Min. Eng. World*, **41**, 1134 (1914).
[3] M. G. F. Sohnlein, *Eng. Min. Jour.*, **97**, 822 (1914); *Min. Sci. Press*, **108**, 847 (1914).
[4] J. Randall, *Min. Sci. Press*, **108**, 417 (1914).

channels in it. A new die with eight channels 1½ in. wide increased the capacity of the pan to 1.7 tons per day through 150 mesh. The effect of the lugs on top of the shoes for fastening them to the muller was found to cause centrifugal force above the shoes and thus reduce the circulation between the shoes and dies. Next the side baffles and a heavy cast-iron feed hopper were removed as being of no value. The pan speed was 68 r.p.m. A further increase of capacity was obtained by reducing the moisture in the feed to 30 per cent., which is only about 5 per cent. more than is necessary to fill the voids between the particles. Finally, an arrangement was installed to give a quick discharge from the pan to a classifier which returned the coarse sand for regrinding. When this point was reached the sizing tests were as follows:

SIZING TESTS OF MILL PRODUCTS

	Stamp Product, Per Cent.	Classifier Spigot Returned to Pan, Per Cent.	Classifier Overflow, Per Cent.
+ 40 mesh	13.3	21.3	0.0
− 40 + 80 mesh	13.9	45.6	1.1
− 80 +100 mesh	8.8	17.0	13.0
−100 +150 mesh	5.9	4.0	10.0
−150 mesh	58.1	12.1	75.9
	100.0	100.0	100.0

It will be seen that the pan is grinding 75.9 minus 58.1, or 17.8 per cent. of the material through 150 mesh, amounting to 4.6 tons in 24 hr. It is also grinding all but 1.1 per cent. of the mill product through 80 mesh. A further very important improvement which may be made is to substitute a universal joint for the rigid connection of the driving spider to the muller. This rigid connection causes the shoes to groove, wear rapidly, and consume more power and at times to cause a chattering of the shoes on the dies. It is reported that in Western Australia pans were a complete failure until this rigid connection was discarded.

Fine Crushing—Tube Mills.—The relative merits of various fine crushing machines, especially tube mills, have received considerable study during the past year and valuable additions made to the knowledge on this subject.

The discussion has included the questions of long or short tube mills, of cylindrical or conical mills, and of quick discharge cylindrical mills or conical mills. The tendency has been to still further shorten the cylindrical mill and thus save power, especially where it is desired to avoid excessive sliming and to obtain a granular product. To attain these same ends there is a tendency in some quarters to increase the feed and water.

The Traylor Engineering and Manufacturing Co. are making mills 4 to 8 ft. diam. and 6 ft. long and have installed several of these sizes.[1] A 7 by 6-ft. mill grinds 200 tons of 6-mesh feed per 24 hr. to 40 mesh, using 50 h.p.

At the Butte and Superior Co. a mill 7 ft. diam. and 10 ft. long over all, crushed 300 tons of dry ore per day.[2] This mill is reported to have been tested against an 8-ft. by 30-in. conical mill, both crushing to 40 mesh, and to have shown its superiority over the conical mill as regards capacity, efficiency and pebble consumption.[3]

Hardinge,[4] in discussing the question of short tube mills, expresses the opinion that no fixed length can be set for all purposes, but that the factors of length, diameter and size and quality of feed are interdependent. Probably the diameter should never be greater than the length. The coarser the product desired the shorter may the mill be made. A mill

FIG. 1.—Chalmers and Williams tube mill discharge.

that is too short will choke unless the capacity is reduced. He cites one case of a mill 6 ft. long by 8 ft. diam. which could not crush fine jig tailing satisfactorily, but which worked all right when the diameter was reduced to 6 ft.

One of the quick-discharging devices which may be used where it is desired to obtain a granular product and high capacity from a cylindrical tube mill is a perforated diaphragm plate such as that made by Chalmers and Williams.[5] This plate is placed 6 in. from the discharge end. In this 6-in. space adjustable shutters are introduced which act as paddles and accelerate the discharge. The claims of the manufacturers, based on detailed comparisons of regular mill work in mills treating similar ores, are that while ordinary cylindrical tube mills make

[1] *Eng. Min. Jour.*, **97**, 812 (1914).
[2] *Eng. Min. Jour.*, **97**, 1149 (1914); *Jour. Chem. Met. Min. Soc. So. Afr.*, **15**, 80 (1914).
[3] A. W. Catlin, *Min. Mag.*, **11**, 184 (1914).
[4] *Min. Sci. Press*, **109**, 218 (1914).
[5] J. J. Wile, *Min. Eng. World*, **40**, 843, 990 (1914); *Min. Mag.*, **11**, 115 (1914); *Eng. Min. Jour.*, **97**, 571 (1914). W. B. Easton, *Eng. Min. Jour.*, **97**, 723 (1914); *Jour. Chem. Met. Min. Soc. So. Afr.*, **14**, 501 (1914).

about 5 per cent. more slimes than conical mills, the cylindrical mills with quick discharge make 25 per cent. less slime than conical mills; that a conical mill uses over 15 per cent. more power and has twice the pebble consumption of the quick-discharge mill; and that under the same conditions it costs 2 to 3½ cts. more to grind a ton of ore from ¼ in. to 20 mesh in a conical mill than in a quick-discharge mill. A conical mill may reduce the percentage of slime in its product by increasing the amount of water, but this is believed to reduce the power efficiency.

The manufacturers of conical mills take issue with some of the above claims and show data leading to different conclusions.[1] It is hoped that impartial tests may soon be made to settle the controversy.

At the McKinley Darragh mill at Cobalt a 5 by 14-ft. Chalmers and Williams tube mill with adjustable quick discharge is used for regrinding jig tailings which pass through 4 mesh and remain on 20 mesh; an 8-ft. by 18-in. Hardinge mill treats a stamp product between 4 and 8 mesh and a Gates tube mill 5 by 20 ft. treats table tailings between 8 and 40 mesh.[2] Liners of the Globe type are used in the tube mills and El Oro lining in the conical mill except for 5 ft. at the apex end. These mills are all used to deliver granular products for concentration.

The quick-discharge device of the Chalmers and Williams mill proved unsatisfactory and was discarded because the flow sheet in use did not call for a return of the coarser part of the discharge from this mill.

The conical mill is elevated 6½ in. at the feed end and no trouble is met in obtaining a granular product by using more feed water and rapid feed up to the point where the mill chokes. Under similar conditions the Gates tube mill delivers a granular product, and in the product of both the conical and the Gates mills the coarse material that is too coarse for satisfactory concentration is so small that it may be neglected.

TABLE I

	Feed, Per Cent.	Product with Diaphragm with Small Holes, Per Cent.	Product after Diaphragm Removed, Per Cent.
+ 6 mesh	32.78	.....	.....
+ 8 mesh	22.05	.....	.....
+ 10 mesh	17.39	.....	.....
+ 14 mesh	11.11	.....	.....
− 14 mesh	16.46	.....	.....
+ 48 mesh	.....	9.57	6.09
+ 65 mesh	.....	13.20	7.85
+100 mesh	.....	16.88	14.58
+150 mesh	.....	13.87	17.60
−150 mesh	.....	46.48	55.96

[1] H. W. Hardinge, *Min. Eng. World*, 40, 946 (1914); *Min. Mag.*, 11, 323 (1914). A. E. Drucker, *Min. Mag.*, 10, 355 (1914). J. C. Farrant, *ibid*, p. 429.
[2] J. G. Mueller, *Eng. Min. Jour.*, 98, 564 (1914).

le I shows sizing tests of feed and products of Chalmers and s mill treating 35 tons in 24 hr., before and after removal of quick-ge device.

le II shows the feed and product of the same mill after a classifier en installed for returning the coarse sand. The feed in this a mixture of jig tails, table middlings and return.

TABLE II

	Feed.			Product.	
	Jig Tailings, Per Cent.	Table Middlings, Per Cent.	Return, Per Cent.	32.4 Tons in 24 Hr., Per Cent.,	52.5 Tons in 24 Hr., Per Cent.
1.....	0.49	.....	.....	.....	.....
1.....	30.49	.....	.....	.....	0.14
1.....	21.07	.....	.....	0.02	0.19
1.....	19.85	.....	.....	0.05	0.19
1.....	12.78	.....	.....	0.07	0.29
1.....	8.05	.....	.....	0.10	0.62
1.....	4.63	.....	6.00	0.38	1.95
1.....	2.64	10.48	7.36	0.95	4.10
1.....	.....	11.45	20.88	3.25	9.29
1.....	.....	13.91	25.51	6.49	12.67
1.....	.....	18.12	24.49	13.56	15.38
1.....	.....	17.68	9.61	16.23	12.48
1.....	.....	11.93	6.10	11.89	6.00
1.....	.....	16.43		47.01	36.52

le III shows the results from the Hardinge mill when fed with e material as in Table II. No. 1 product was obtained when the s 32.4 tons in 24 hr. with 25 gal. water per min., and No. 2 when s 56.16 tons with 30.4 gal. water.

TABLE III

	Feed, Per Cent.	Product No. 1, Per Cent.	Product No. 2, Per Cent.
1.....	5.15	.....	.....
1.....	36.01	.....	.....
1.....	18.39	.....	.....
1.....	14.61	.....	.....
1.....	8.94	.....	.....
1.....	7.46	.....	.....
1.....	9.42	.....	.....
1.....	.....	0.05	0.05
1.....	.....	0.14	0.19
1.....	.....	0.44	0.57
1.....	.....	1.71	2.71
1.....	.....	3.95	5.76
1.....	.....	9.81	13.71
1.....	.....	11.67	12.81
1.....	.....	15.58	14.52
1.....	.....	12.60	10.86
1.....	.....	6.10	6.19
1.....	.....	37.94	32.63

Table IV shows the Hardinge mill on its regular work treating 33.27 tons in 24 hr. of a mixture of sized material from stamps and table middlings.

TABLE IV

	Feed.		Product, Per Cent.
	Stamp Stuff, Per Cent.	Table Middlings, Per Cent.	
+ 6 mesh	27.24		
+ 8 mesh	32.05		
+ 10 mesh	28.33	12.75	
+ 14 mesh	7.38	7.99	
− 14 mesh	5.00		
+ 20 mesh		6.03	
+ 28 mesh		10.69	
+ 35 mesh		10.05	
+ 48 mesh		13.09	
+ 60 mesh			11.63
+ 65 mesh		8.47	
+ 80 mesh			16.49
+100 mesh		11.37	16.36
+150 mesh		11.03	2.88
+200 mesh		4.85	4.29
−200 mesh		3.68	48.24

Perhaps the extreme development in tube mills is that represented by the so-called Marcy ball mill, twenty of which are being installed in the mill of the Inspiration Copper Co. These mills are made in sizes 4, 6 and 8 ft. diam. and 26, 42 and 60 in. long, respectively. Steel balls are used for crushing and the inside of the mill is lined with hard steel plates in step form like shingles. They take wet feed through a scoop feeder and the feed may be as coarse as 2 or 3 in. The discharge is through a vertical grating inside the mill near the discharge end, and the material passing through this grating together with the water is raised by radial ribs or lifters to issue through the central discharge trunnion. The product is easily made as fine as 20 mesh, and by installing a classifier or screen for returning the coarse material this can be reduced to 100 mesh. One interesting feature of this mill is the removal of water by the lifters with the resulting effect that the water line inside the mill, instead of being level with the discharge opening, is perhaps two-thirds of the distance down from the center of the mill to the bottom.

Details of the four 6 by 20-ft. tube mills in the Nipissing Mill have been published.[1] The two coarse-grinding mills are fed with a mixture of flint pebbles and hard ore pebbles selected from the run of mine ore. The average consumption per ton of ore crushed is 1.8 lb. of flint pebbles plus 2 lb. of ore pebbles. The two fine-grinding mills are charged with only flint pebbles which wear at the rate of 4.3 lb. per ton of ore crushed. All four tube mills are lined with silex blocks 4 in. thick.

[1] J. Johnston, *Bull. Amer. Inst. Min. Eng.*, 85, p. 107, Jan., 1914.

Sizing tests are as follows:

	Coarse Mill.		Fine Mill.	
	Feed, Per Cent.	Discharge, Per Cent.	Feed, Per Cent.	Discharge, Per Cent.
+ 20 mesh	57.02	5.8	2.12	0.4
− 20 + 100 mesh	28.86	27.06	21.46	12.43
−100 + 200 mesh	7.22	14.86	30.96	19.76
−200 mesh, sand	5.21	19.30	41.19	38.27
−200 mesh, slime	1.67	32.18	3.11	28.23

The innovation in California of using two Hardinge mills with thirty stamps in two-stage crushing at the new Plymouth has been already mentioned. The mill tailings from amalgamation and concentration show the following sizes and assays:

	Per Cent.	Assay per Ton.	Per Cent. of Total Value.
On 40 mesh	2.36	$0.60	3.1
On 60 mesh	4.36	0.60	5.7
On 80 mesh	14.30	0.40	12.3
On 100 mesh	10.92	0.20	4.7
On 200 mesh	32.81	0.40	28.4
Through 200 mesh	35.25	0.60	45.8
Total	100.00	$0.46	100.0

Of the minus 200-mesh material about one-half is fine sand and one-half is colloids. The losses come chiefly in the colloids. The two-stage crushing, using coarse stamps with the non-sliming Hardinge mills, yields 95 per cent. of the ore through 60 mesh with only 18 per cent. colloids. Stamps alone crushing to this size would require about 32-mesh screens and would yield a larger proportion of colloids. The stamp duty would be about 4 tons per day and thus 75 stamps would be required to crush 300 tons, which is the present capacity of the mill, when running 25 stamps and the two Hardinge mills.

The cost of grinding per day by the Hardinge mills is as follows:

Danish pebbles, 400 lb. at $1.25	$5.00
Pebble lining (3 months), 6 tons	1.67
Placing lining	1.00
Power, 90 h.p. at $4.50	13.50
Labor, 1.5 hr. at 35 cts	0.52
Oil and grease	0.04
Belts, 200 ft. in 12 months	1.07
Total cost per day	$22.80
Cost per ton milled	0.076

Local river pebbles costing $4 per ton are now used instead of Danish pebbles at $27 per ton, but the consumption is three times greater.

Assuming that the mill corresponds to an ordinary 75-stamp mill crushing 300 tons, then the two Hardinge mills are doing the work of 50 ordinary stamps, equivalent to 200 tons per day, which corresponds to a cost of 11.4 cts. per ton for the share of work that the Hardinge mills are doing and compares favorably with the cost of stamping. Further, the Hardinge mills require very little attention.

In the Lake Superior native copper district the Hardinge mills have the field almost entirely to themselves for regrinding sand tailings,[1] having replaced Chile mills formerly used. Over 150 conical mills are either in use or are to be installed in the district. They are operated more cheaply and give a better product for concentration than the Chile mills. Since they are run for a granular product the ratio of water to ore is 3 or 4 to 1. The following sizing tests of the feed and product of an 8-ft. by 30-in. Hardinge mill, treating 2.53 tons per hr., are illustrative of the work that these mills are doing:

Mesh	+10	+20	+40	+60	+100	+200	−200
Feed, per cent	35	18	7	8	13	11	8
Product, per cent	.....	1	3	9	21	33	33

The Calumet and Hecla Co. has in one plant 64 mills grinding and one spare mill, besides two extra foundations. When a mill needs relining it is transferred bodily by a crane to one of these foundations and a newly relined mill transferred from the other spare foundation to take the place of the worn-out mill.

At the Mary Murphy Mill, Colorado, an opportunity has been had to compare a 3½ ft. by 16-ft. Gates tube mill, two 6-ft. by 22-in. Hardinge mills and one 4-ft. by 22-in. Hardinge.[2] The capacities of the tube mill and the 6-ft. Hardinge, using the same feed, are almost identical, and the cost of the Hardinge was about 20 per cent. greater. The Hardinge uses more pebbles and has to be relined oftener. Mr. Collins refutes the claim that the Hardinge mill grades its crushing according to the diameter, and states that any crushing that occurs at the small end comes by abrasion and can not be caused by impact owing to the low peripheral speed corresponding to the small diameter. What the cone really does is to accelerate the discharge and reduce sliming. Nearly this same result may be obtained in a cylindrical tube mill by using a

[1] A. Del Mar. *Min. Sci. Press*, 109, 511, 513, 884, 963 (1914).
[2] G. E. Collins, *Col. Sci. Soc.*, 10, 431 (1914); *Min. Sci.* 69, 55. June, 1914; *Mex. Min. Jour.*, 18, 354 (1914); *Eng. Min. Jour.*, 97, 240 (1914).

quick-discharging device and by crowding the feed and using a large amount of water. The effect of capacity is shown in the following sizing tests of the 4-ft. Hardinge mill treating jig middlings containing galena and blende. In Case A the mill was treating 34.6 tons in 24 hr. assaying 5 per cent. lead and 10.9 per cent. zinc, while in Case B it was treating 14.04 tons assaying 20.2 per cent. lead and 22.6 per cent. zinc. The conditions of the mill were the same in both cases.

	Case A.		Case B.	
	Feed Per Cent.	Discharge Per Cent.	Feed Per Cent.	Discharge, Per Cent.
On 10 mesh	32.6	3.0	66.0	0.0
On 100 mesh	62.1	68.1	44.0	4.5
On 200 mesh	3.5	16.8	0.0	22.7
Through 200 mesh	1.8	12.1	0.0	72.8

In Case B 75 per cent. of the silver, 84.7 per cent. of the lead and 68.9 per cent. of the zinc was in the material finer than 200 mesh. This soft leady material is believed to be unsuited to grinding in a Hardinge mill, and therefore rolls are to be used on this middling product but pebble grinding is to be retained on the hard jig tailings.

The limits to which pebble grinding may go are indicated by the installation of 8-ft. by 30-in. Hardinge conical mills in the Commonwealth Mill at Pearce, Arizona, to receive a product through 2-mesh stamp screen and to crush it to 20 mesh. At Leadville, Colorado, in the Mount Champion Mill the feed to an 8-ft. by 22-in. Hardinge mill is from a Symons breaker and has 10.35 per cent. coarser than ¾ in. and 92.7 per cent. coarser than 4 mesh. The Hardinge mill grinds 50 to 60 tons of this material per 24 hr. to a point where 69.6 per cent. will pass through 100 mesh.[1]

A very interesting study of the relation of capacity to tube mill efficiency has been made by R. T. Mishler on the 5 by 14-ft. tube mills at the Lucky Tiger Mill.[2] These mills have El Oro manganese steel liners. The method of computing results is practically the "mesh reciprocal" method of Del Mar and Gates in which the total work of crushing represented by any lot of ore is calculated by a summation of the products of the percentages of each size by the reciprocal of that size in inches. The difference between these calculated summations for the feed and discharge of a crushing machine is the work done per ton by that machine.

[1] *Min. Eng. World*, **40**, 1119, (1914).
[2] *Eng. Min. Jour.*, **98** 469 (1914).

The following tables show results on coarse, fine and mixed feeds.

TABLE I.—COARSE FEED

Test No.	1		2		3		4	
Tons dry feed per day	22		47		70		85	
Liquid: sand ratio	1.1 : 1		0.94 : 1		0.84 : 1		0.90:1	
	Feed.	Disch.	Feed.	Disch.	Feed.	Disch.	Feed.	Disch.
Per cent. on 20 mesh	11.2	0.3	21.6	0.2	18.4	.....	22.4	.....
Per cent. on 40 mesh	28.0	0.6	39.6	0.6	45.2	0.4	39.4	0.6
Per cent. on 60 mesh	25.6	1.4	23.0	0.8	19.6	4.0	20.6	5.2
Per cent. on 80 mesh	13.4	0.4	3.8	2.2	5.0	4.2	4.2	6.2
Per cent. on 100 mesh	6.0	1.2	2.4	2.9	2.8	5.4	2.6	6.8
Per cent. on 150 mesh	4.6	2.4	2.2	5.4	1.8	8.4	1.2	9.6
Per cent. on 200 mesh	3.6	2.6	1.0	4.9	1.2	6.2	0.8	4.8
Per cent. through 200 mesh	7.6	91.1	6.4	83.0	6.0	71.4	8.8	66.8
Work units in feed	113		82		81		87	
Work units in discharge	381		367		341		326	
Difference = work done per ton	268		285		260		239	
Tons × difference = work done per day	5,896		13,395		18,200		20,315	

Power constant at 47 h.p.

TABLE II.—MIXED COARSE AND FINE FEED

Test No.	1		2		3	
Tons dry feed per day	45		103		145	
Liquid : sand ratio	0.44 : 1		0.46 : 1		0.57 : 1	
	Feed.	Disch.	Feed.	Disch.	Feed.	Disch.
Per cent. on 20 mesh	0.8	.....	1.0	.....	1.0	.....
Per cent. on 40 mesh	3.6	.....	8.4	.....	5.4	.....
Per cent. on 60 mesh	18.8	0.4	18.4	2.2	17.4	4.4
Per cent. on 80 mesh	14.2	2.0	13.6	5.2	18.0	8.8
Per cent. on 100 mesh	15.0	6.0	13.8	9.8	17.0	12.8
Per cent. on 150 mesh	14.8	10.0	14.2	13.0	16.0	16.4
Per cent. on 200 mesh	11.2	11.6	10.2	12.0	10.2	13.4
Per cent. through 200 mesh	21.6	70.0	20.4	57.8	15.0	45.8
Work units in feed	213		203		194	
Work units in discharge	350		320		293	
Difference = work done per ton	137		117		99	
Tons × difference = work done per day	6,165		12,051		14,355	

Power constant at 47 h.p.

TABLE III.—FINE FEED

Test No.	1		2		3	
Tons dry feed per day	109		217		570	
Liquid : sand ratio	0.47 : 1		0.49 : 1		0.53 : 1	
	Feed.	Disch.	Feed.	Disch.	Feed.	Disch.
Per cent. on 20 mesh	0.52	.....	0.76	.....	0.42	.....
Per cent. on 30 mesh	0.08	0.08	2.72	0.28	1.76	0.60
Per cent. on 40 mesh	4.52	0.44	3.40	1.04	3.60	2.56
Per cent. on 60 mesh	6.48	2.96	7.24	4.64	10.92	10.56
Per cent. on 80 mesh	9.44	5.44	7.76	6.68	13.08	11.08
Per cent. on 120 mesh	27.36	19.20	25.40	22.60	29.60	30.52
Per cent. on 150 mesh	30.60	32.96	31.20	34.28	24.86	25.20
Per cent. on 200 mesh	12.44	18.88	13.28	13.92	9.28	9.20
Per cent. through 200 mesh	8.56	20.04	8.24	16.56	6.48	10.28
Work units in feed	218		216		198	
Work units in discharge	264		248		212	
Difference = work done per ton	46		32		14	
Tons × difference = work done per day	5,014		6,944		7,980	

Power constant at 45.5 h.p.

TABLE IV.—FINE FEED

Test No.	1		2		3		4	
Tons dry feed per day	67		80		239		693	
Liquid : sand ratio	0.45 : 1		0.44 : 1		0.46 : 1		0.55 : 1	
	Feed.	Disch.	Feed.	Disch.	Feed.	Disch.	Feed.	Disch.
Per cent. on 20 mesh	0.20	.....	0.32	.....	0.51	.....	0.99	0.19
Per cent. on 30 mesh	0.76	.....	0.96	.....	1.08	0.40	2.23	1.14
Per cent. on 40 mesh	1.72	.....	2.12	0.40	2.21	1.00	4.52	3.42
Per cent. on 60 mesh	4.40	1.10	7.20	1.80	6.43	4.65	11.48	10.81
Per cent. on 80 mesh	8.56	2.85	12.46	4.25	12.78	9.05	12.78	12.96
Per cent. on 120 mesh	25.76	14.75	28.40	19.00	30.71	27.50	27.98	28.50
Per cent. on 150 mesh	30.20	25.78	27.18	29.30	24.98	27.05	24.92	24.63
Per cent. on 200 mesh	17.90	25.49	12.82	15.10	12.62	14.35	9.59	10.26
Per cent. through 200 mesh	10.50	30.03	8.54	30.15	8.68	16.00	5.51	8.09
Work units in feed	234		216		214		194	
Work units in discharge	293		281		241		205	
Difference = work done per ton	59		65		27		11	
Tons × difference = work done per day	3,952		5,200		6,543		7,623	

Power constant at 44.8 h.p.

What these figures actually mean is that by increasing the tonnage, the fineness of the grinding is decreased, but that by returning the coarser part of the discharge for further grinding, the net efficiency of the mill is increased. With a low rate of feed a particle may be reduced in one passage through the mill, but with a high rate the particle may be returned several times before it finally receives the desired reduction in size. The low rate must produce more of the impalpable sizes which are too fine for measurement but which use up a lot of power. The advantage of increased tonnage in increasing efficiency may be continued almost indefinitely, but practically a limit is reached where the gain is small, that is, where the return to the mill is all out of proportion to the initial feed, and where the expense of elevating, classifying and returning this coarse material becomes a large factor. The economical limit is set by Mishler at 200 tons total feed per 24 hr. made up of 50 tons initial feed and 150 tons return.

The economical aspects are indicated in Tables V and VI, the former showing the proportions of total feed and return feed using 5, 4, 3 and 2 mills respectively to handle in each case 150 tons of dry initial feed per 24 hr. and the latter showing the saving in pebbles and total costs with the larger tonnage.

TABLE V.—RELATION OF FEED TO RETURN
(150 tons initial feed in each case)

Tube Mills Operating.	Total Tons Dry Feed per Mill.	Total Tons Dry Feed to all Mills.	Total Return Feed.
5	40	200	50
4	80	320	170
3	200	600	450
2	600	1,200	1,050

TABLE VI.—EFFECT OF INCREASED CAPACITY ON PEBBLE CONSUMPTION AND COSTS

	Average Tonnage Initial Feed per Mill.	Approx. Tonnage Initial plus Return Feed per Mill.	Pounds Quarry Rock per Ton Initial Feed.	Pounds Pebbles per Ton Initial Feed.	Cost per Ton Initial Feed for Tube Milling, Elevating and Classifying.
First 3 months	.....	.....	Data not	complete	.....
Next 6 months	26.1	35	10.0	17.9	$1.88
Next 9 months	40.3	80	None	15.8	1.01
Next 12 months	42.0	85	None	15.3	0.94
Last 3 months	50.0	200	None	8.2	0.68

An opposing opinion to that of increasing the moisture in tube-mill feed is held by W. J. Pentland[1] who believes that for sliming purposes the inefficient discharge which results when the moisture is reduced may be offset by increasing the slope. He states that where too much water is used the fine sand is kept in suspension without being ground and only the coarse sand is efficiently acted on by the pebbles. This fine sand has to be returned to the mill several times before it is slimed. He cites an example of a mill with 200 stamps and nine tube mills. The stamps had 25- and 35-mesh screens and yielded 50 to 55 per cent. through 200 mesh, while the final tube-mill product had 80 per cent. through 200 mesh. The total capacity of the mill was 730 to 750 tons in 24 hr. By hanging up 100 stamps and substituting 8- and 10-mesh screens and adding three more tube mills, the total tonnage was 1050 tons, and only 30 to 33 per cent. of the stamp pulp was through 80 mesh, but the final tube-mill product still had 80 per cent. through 200 mesh. The net capacity per tube mill of product through 200 mesh was 25 tons per 24 hr. in the first case and 42 tons in the second. Although not directly stated, the reader is led to understand that the moisture in the tube-mill feed was 38 per cent. in the first case and 31 or 32 per cent. in the second case. No exact figures are given on power consumption in the two cases. It is generally held, however, that the thicker the pulp the more the power required for the tube mill.

A valuable detailed review of tube-mill practice has been published by H. S. Gieser.[2] He covers the development of tube milling and discusses the sizes used in various districts, the liners, pebbles, speeds and costs on different ores and under varying conditions.

Detailed figures on costs, weights and specifications of tube mills as obtained from seven different manufacturers have been published by P. E. Barbour.[3]

An end lining for tube mills[4] has been made of an outer circle of

[1] *Met. Chem. Eng.*, **12**, 750 (1914).
[2] *Eng. Min. Jour.*, **97**, 463 (1914); *Min. Sci.*, **69**, p. 44, April, 1914.
[3] *Eng. Min. Jour.*, **98**, 873 (1914).
[4] J. F. Pyles, *Jour. Chem. Met. Min. Soc. So. Afr.*, **15**, 23 (1914); *Met. Chem. Eng.*, **12**, 784 (1914).

6-in. chert blocks with the space between the blocks and the opening at the center of the end of the mill filled in with alternate horizontal layers of steel pegs 6 in. long and pine boards 1 in. thick and 6 in. wide. The pegs and boards are imbedded in mortar. The pegs are laid with their length parallel to the axis of the mill and the boards are laid flat.

The lining for conical tube mills which has been adopted finally at Miami consists of a ribbed cast-iron lining in the cylindrical part of the mill and in the first portion of the conical discharge end; pebbles imbedded in cement are used for the remainder of the discharge cone and also for the cone at the feed end of the mill. The ribbed cast-iron lining in the cylindrical portion has lifter bars projecting 2½ in. above the ribs; these take much of the wear and also have a beneficial effect on the grinding. The life of these linings is estimated to be double that of silex linings. Other linings which have been tried and discarded are: a patented manganese-steel-plate lining with ribs or lifter bars; a flat cast-iron lining which was too smooth; and an all-pebble or cement lining.[1]

The Globe tube-mill liner which is favored at Cobalt and Porcupine is of the ribbed type but the chilled-iron ribs instead of being parallel to the axis of the mill are circumferential to the shell of the tube.[2] Further, these ribs are tapered so that the grooves between them widen toward the direction of rotation of the mill with the resulting effect that the pebbles are automatically and quickly picked up and jammed securely into the grooves.

The war has affected the importation of foreign pebbles for tube mills and has given added impetus to the use of local material. At the Maris quarry near Manhattan, Nevada, chalcedony is mined, made into pebbles and sized for use at Tonopah and Goldfield where this local material is found to be equal to Danish pebbles in most cases.[3]

It is also reported that steel balls of special manganese or chrome steel are giving favorable results in comparison with pebbles. Of course these can not be used in any process where finely ground iron would have a deleterious effect.[4]

Theory of Crushing.—The importance of careful crushing of a coarsely disseminated ore to avoid losses in fines is not always appreciated. Fines are produced from such ores in the following ways: Improper methods of crushing, including too great a reduction in one operation; by inefficient screening due usually to too little screen capacity; by unnecessary recrushing of middlings; and by carelessness in breaking ground in the mine,

[1] *Eng. Min. Jour.*, **97**, 567 (1914).
[2] J. G. Mueller, *Min. Sci. Press*, **109**, 255 (1914); *Jour. Chem. Met. Min. Soc. So. Afr.*, **15**, 140 (1914); *Eng. Min. Jour.*, **98**, 393 (1914).
[3] *Eng. Min. Jour.*, **98**, 1078 (1914).
[4] *Eng. Min. Jour.*, **98**, 1151 (1914).

such as drilling holes directly into the friable mineral or using too high power explosive. Instances are given of two Wisconsin zinc mills, one of which makes tailings containing 30.9 per cent. through 40 mesh and extracts not over 60 per cent. of the zinc, while the other by close attention to the above precautions has only 9.3 per cent. of the tailings through 40 mesh and recovers 85 per cent. of the zinc.[1]

A simple and accurate method of comparing the hardness of ore sand in grinding, especially in tube milling, has been advanced by W. B. Blyth.[2] His method consists of taking a wet crushed sample of the ore to be tested (dry crushing produces angular fragments) and sizing it by a standard set of screens whose apertures are known, until 8 lb. of material is obtained which passes through 20 mesh and rests on 40 mesh. This is charged with 8 lb. of flint stones, 1 to 2 in. diam., and 16 lb. of water into a 5-gal. glazed earthenware ginger beer barrel and ground for 90 min. at 60 r.p.m. A sample of the ground product is then taken, dried, and graded mechanically, using 40-, 60-, 100- and 150-mesh standard screens. Grading occupies 20 min. The value of the grading in energy units is then calculated by the Stadler method (see MINERAL INDUSTRY, 19, 748) and this amount, minus the original value in energy units, represents the regrinding factor. This is shown in the following table:

Screen, Mesh.	Feed.			Product.		
	Mesh Factor, Stadler.	Per Cent.	Energy Units.	Per Cent.	Mesh Factor, Stadler.	Energy Units.
+ 40	17.5	100	1750	16.8	17.5	294.0
+ 60	.....	.....	.....	29.2	20.0	584.0
+100	.....	.....	.....	16.4	22.0	360.8
+150	.....	.....	.....	6.6	24.0	158.4
−150	.....	.....	.....	31.0	26.5	821.5
			1750	100.0		2218.7

Regrinding factor, 2218.7 minus 1750, or 468.7.

Obviously, for universal application this method requires exactly the same conditions of apparatus, size and hardness of grinding flints, standard screens and duration of grading. Blyth used I.M.M. screens but Tyler screens may be used just as well. If Kick's law, on which Stadler's units are based, should later prove untenable for crushing, then some other method of mathematical application will be equally applicable.

The controversy between the followers of Kick and Rittinger still goes on and, although the year has produced considerable discussion, no

[1] H. A. Roesler, *Mex. Min. Jour.*, 18, 293 (1914).

[2] *Jour. Chamber of Mines, Western Australia*, p. 88, April, 1914; *Jour. Chem. Met. Min. Soc. So. Afr.*, 15, 10 (1914); *Mex. Min. Jour.*, 18, 353 (1914); *Met. Chem. Eng.*, 12, 537 (1914); *Min. Sci. Press*, 109, 93 (1914).

arguments or results of tests of either side have been sufficient to satisfy the opposing side.

H. Stadler[1] has again defended Kick's law and the application of the Stadler ordinal numbers or energy units in computing crushing efficiencies.

G. H. Stanley[2] has analyzed Rittinger's theory and Kick's law from a new angle of view and cites the results of some experiments on dropping pebbles of different sizes from constantly increasing heights until rupture took place. He favors Kick's law.

S. J. Speak[3] favors Kick's law, although believing that both it and the Rittinger theory cannot be exactly applied in practice owing to the increasing tenacity claimed for very fine material, and also owing to the fact that no ore is absolutely homogeneous. The result is that even Kick's law will overestimate the energy consumed in coarse crushing; it will underestimate the energy consumed in the grinding of non-slimy sand into slime; and it will overestimate the work done in making slime from such ores as contain slime as an original constituent.

A. O. Gates[4] has elaborated on his crushing surface diagram (see MINERAL INDUSTRY, **22**, 823), and has invented new terms such as "mesh-gram" to denote the surface produced by a theoretical crushing operation in which 1 gm. of particles of the same diameter is all reduced to a diameter whose reciprocal is one greater than before reduction. Similarly, the terms "mesh-tons," "mesh-pounds," etc., are defined where other units of weight are used. His work is all based on the Rittinger theory, the truth of which he considers is fully proved by the data from his experimental work on crushing rock in a testing machine, considered in conjunction with his mathematical calculations on the probable proportions of fine material beyond the limits of actual measurements.

SCREENING AND CLASSIFYING

Trommels.—The factor of speed of revolution of a trommel acts in two ways. Where the speed is too low, the bank of ore is too thick and poor screening results; when it is too high, centrifugal force causes blinding and results in poor screening. This has been shown in a practical way by H. A. Roesler[5] who made tests on a trommel 3 ft. diam., 12 ft. long, sloping 1¼ in. per ft. and punched with ½-in. round holes. The percentage of opening was 40.3 per cent. The rate of feed was practically constant between 22 and 24 tons per 24 hr. Results obtained by varying the speed were as follows:

[1] *Eng. Min. Jour.*, **98**, 905, 945 (1914).
[2] *Jour. Chem. Met. Min. Soc. So. Afr.*, **15**, 24 (1914); *Met. Chem. Eng.*, **12**, 783 (1914).
[3] *Inst. Min. and Met.*, **23**, 482 (1914); *Can. Min. Jour.*, **35**, 623 (1914); *Met. Chem. Eng.*, **12**, 481 (1914); *Min. Eng. World*, **41**, 51 (1914); *Mex. Min. Jour.*, **18**, 265 (1914).
[4] *Eng. Min. Jour.*, **97**, 795, 821 (1914).
[5] *Eng. Min. Jour.*, **98**, 305 (1914).

Speed, r.p.m.	22.0	19.8	17.6	15.4	13.2	11.0
Feed, per cent. + ½ in.	26.9	25.1	26.2	25.3	27.4	24.9
Feed, per cent. − ½ in.	73.1	74.9	73.8	74.7	72.6	75.1
Oversize, per cent. + ½ in.	64.3	67.8	74.5	75.3	73.4	66.9
Oversize, per cent. − ½ in.	35.7	32.2	25.5	24.7	26.6	33.1
Efficiency, per cent	79.6	84.2	87.8	88.9	86.4	83.7

The efficiency is calculated on the amount of actual undersize as compared to the amount of material below ½ in. in the feed.

Sizing without Screens.—It is reported that the Sutton, Steele and Steele Co. have discarded screens entirely and are using a corrugated belt satisfactorily for dry sizing in their Denver plant.[1]

Grading Analyses.—In making screening tests it is recognized that there is always a possibility of obtaining varying results, depending on the personal factor of the operator. For this reason the U. S. Bureau of Standards specifies for cement work the exact mode of operation.[2] Other standard directions have been published from time to time. L. Robey[3] has found the following method satisfactory during 3 years' trial. The finest screen of the series is taken first and held under a small stream of water. The pulp is fed slowly near the stream and the screen is shaken gently at the same time. Next the oversize is dried and screened dry over the same screen until no more undersize comes through. The final oversize is sized on the coarser screens, shaking each screen until no undersize comes through. No method of wet screening will give as accurate results as the above method. It is advisable to discard the finest screen after about 100 determinations, because the repeated oxidations and scourings wear the wire and enlarge the aperture.

For grading cyanide pulp at the Nipissing mill into sands coarser than 200 mesh, sands finer than 200 mesh and slimes, an elutriation device is used.[4] This consists of three tin cones, respectively 5.5, 7 and 10.5 in. diam. at the top, with a feed water vat to give a 6-in. head. The pulp to be tested is fed slowly into the first or smallest cone and the apparatus yields three grades of settled products and a final overflow product.

H. Stadler[5] has continued his discussion of the application of elutriation to fine sizes in grading analyses (see MINERAL INDUSTRY, **22**, 825), and has shown how to apply the results to classifier calculations following the lines laid down by Richards.[6]

[1] *Min. Sci.*, **69**, p. 54, Feb., 1914.
[2] *Circular* No. 33, U. S. Bureau of Standards, pp. 10, 23.
[3] *Min. Sci. Press*, **108**, 533 (1914).
[4] J. Johnston, *Bull. Amer. Inst. Min. Eng.*, **85**, p. 107, Jan., 1914.
[5] *Inst. Min. and Met.*, **23**, 512 (1914). *Min. Eng. World*, **41**, 55 (1914). *Met. Chem. Eng.*, **12**, 536 (1914).
[6] Ore Dressing, Vol. 3, p. 1375.

Classifiers.—In the development of the Stanley classifier (see MINERAL INDUSTRY, **21,** 945) some very valuable data were obtained regarding the actions of hydraulic classifiers and the causes of their imperfections.[1] The experimental work was done in various models with glass sides to allow observation of the movements of the grains. In every case it was found that close to the sides of the pockets and the sorting columns fine material was descending which should go into the overflow, while toward the center the rising current of water was more rapid than at the sides. Take, for example, a hopper-shaped settling pocket, connected to the bottom of which is a vertical cylindrical sorting column. Here the rising water introduced at the lower end of the sorting column was found to have a higher velocity at the center than at the sides. The result was that particles of fine material which belonged in the overflow settled down to the sloping sides of the pocket and then slipped down into the sorting column, clinging close to its sides and being helped in their descent by the accompanying coarser particles, until they finally issued through the spigot. This explains the presence of fine material which is almost always found in the spigot products of mill classifiers. Stanley found that by increasing the ratio of sand to water, either by increasing the feed or by other means, the conditions gradually changed from free settling toward hindered settling, and that there was less tendency for the water to seek the center of the tube and in consequence the fine particles could not descend at the sides as readily as before, although occasionally a mass of coarse and fine would descend in a lump and carry fines into the spigot. The conclusion from all this work is that hindered settling gives less contamination of the spigot product than free settling, and that the best classifier is the one which thoroughly agitates the pulp to break up masses and at the same time has a good rising current close to the walls of the sorting column.

At the Miami copper mill the Deister cone-baffle classifier has been installed.[2] This is of the launder or trough type, and its marked feature is in the form of the sorting column which is a cast-iron barrel slightly larger at the top where it joins the bottom of the pocket in the launder or trough than at the bottom where the hydraulic water is introduced. Inside this barrel hollow cones or diaphragms, with slots sufficiently large to permit the free passage of the coarser material, are placed in an inverted position. These pots or cones are staggered, the slots in one cone being out of line vertically with the adjacent cones, thus forming baffles. The object of this arrangement is to give a thorough agitation to the spigot material as it descends through the sorting column. Sizing

[1] G. H. Stanley, *Jour. Chem. Met. Min. Soc. So. Afr.*, **14,** 445, 484 (1914); **15,** 34, 57, 95 (1914).
[2] *Eng. Min. Jour.*, **97,** 910 (1914); *Min. Sci. Press*, **108,** 1057 (1914); *Jour. Chem. Met. Min. Soc. So. Afr.*, **15,** 12 (1914).

tests of a spigot product show 78 to 83 per cent. between 30 and 60 mesh and 3 to 6 per cent. finer than 100 mesh.

H. A. Megraw has discussed the relative use and merits of cone classifiers, mechanical clasifiers and fine screens in grading pulp for cyaniding.[1]

Hand Sorting, Log Washers, Jigs and Tables

Log Washers.—The Freygang apparatus combines the actions of a log washer and a classifier.[2] It consists of an enclosed cylinder mounted so as to allow adjustment of its inclination. Inside this cylinder is a revolving shaft with the usual log washer blades which in this case are in the form of a continuous helical screw. Near the lower end is a vertical rising pipe through which the feed and water are introduced. About midway or a little below is a second vertical pipe through which the fine material and water overflow. The upper end of the cylinder is open for the discharge of the coarse product. Water pipes for washing are inserted in the walls of the cylinder along the upper half of its length. The level of the overflow is below the top of the feed pipe and also below the level of the upper end of the cylinder, so that all the feed and wash water rise in the overflow pipe and exercise a classifying action. This washer is used on iron ores in upper Hesse and does work superior to that of wash trommels.

Jigs.—A novel application of jigs is reported on the gold dredge of the Yosemite Dredging Co. for saving black sand from the tailings of the gold-saving tables.[3] Various forms of jigs were tried, but the most satisfactory was a two-sieve jig having a vertical hinged paddle in a single compartment beneath the screens. The oscillations of this paddle produce the necessary pulsations alternately to each screen. The jig screens are made of Monel metal specially woven. This material has the advantage that it never corrodes or amalgamates.

Concentrating underground, which hitherto has been limited to hand sorting and to occasional coarse crushing, has been extended in one Joplin zinc mine to include hand jigging.[4]

Riffle Table Tops.—Improvements in riffle tables have been along the line of new forms of table tops and in the use of double-deck tables.

The General Ore Concentrating Co.[5] has brought out the Monel riffles and the glass table top. The Monel riffles are made in any desired thickness like ordinary metal or wood riffles, but the nails are a part of the riffle so that the only work necessary in attaching is to lay the riffle

[1] *Eng. Min. Jour.*, **97**, 845 (1914).
[2] C. Köbrich, *Glückauf*, **50**, 481 (1914).
[3] J. W. Neill, *Min. Sci. Press*, **109**, 839 (1914).
[4] *Min. Eng. World*, **41**, 99 (1914).
[5] A. Schwarz, *Min. Eng. World*, **41**, 391 (1914); *Eng. Min. Jour.*, **98**, 307, 308 (1914).

on the table and to pound it down. There are no projecting nail heads to interfere with the concentration and the riffles cannot work loose, as occurs with ordinary riffles when the nail heads wear off. The price is 5 cts. per linear ft., f.o.b., New York.

The glass table top is made of a special strong and elastic-wire-reinforced glass, $\frac{3}{8}$ in. thick, having eight corrugations or riffles per in. The riffles are 0.06 in. deep but, contrary to usual practice, they diminish in height as the feed end of the table is approached. The section of the table top directly under the feed box is made of linoleum, concrete or rubber. The action of these riffles is such that the bulk of the concentrates comes off high on the table and leaves a section of considerable width between the main body of the concentrates and the tailings where only lean middlings pass over, and no free mineral is found in the middlings. Tests of a glass top with a standard table top at the Miami Mill showed that the glass top saved more concentrates which assayed higher in copper, and thus gave a higher extraction than the standard tables.

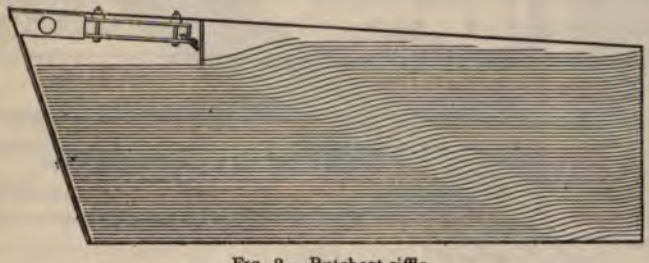

FIG. 2.—Butchart riffle.

The glass surface has the advantage that it is non-corrosive and non-porous and gives satisfactory wear.

The Butchart riffle tables which are being installed at Anaconda, and have been used with satisfactory results in Arizona, differ from the Wilfley table in having riffles the whole length of the table and in having a curve in the riffles (see Fig. 2). The table may be considered in three zones: (*a*) the stratifying zone before the bend, where the riffles are deep; (*b*) the cleaning zone, where the bend occurs; (*c*) the discharge zone where the riffles are shallow, which corresponds to the unriffled surface on the Wilfley table. The riffles are made of wood strips tacked on the table top in the usual manner. The claims made for this table are: (1) increased extraction; (2) an increase in capacity amounting to between 100 and 500 per cent.; (3) high capacity on heavily mineralized ore; (4) better results without classification of feed than with classification; (5) ability to treat coarse feed up to $\frac{1}{4}$ in. in size at which point the coarse feed begins to cause heavy wear of the table.

The Deister sand and slime tables may now be obtained in double-deck forms where it is desirable to save space. The Miami Copper Co. has replaced the single-deck sand tables with double-deck tables in an entire section of their mill.

The Deister Co. has also brought out the Deister plateau and riffle.[1] As shown in Fig. 3, this consists of two steps of elevation placed under the linoleum top and running diagonally across the table. The section shows 4 in. of inclined rise of ¼ in., then 4 in. level and finally 4 in. of inclined rise of 5/16 in. This device may be applied to either Wilfley or Deister tables. The riffles are set closer together than on

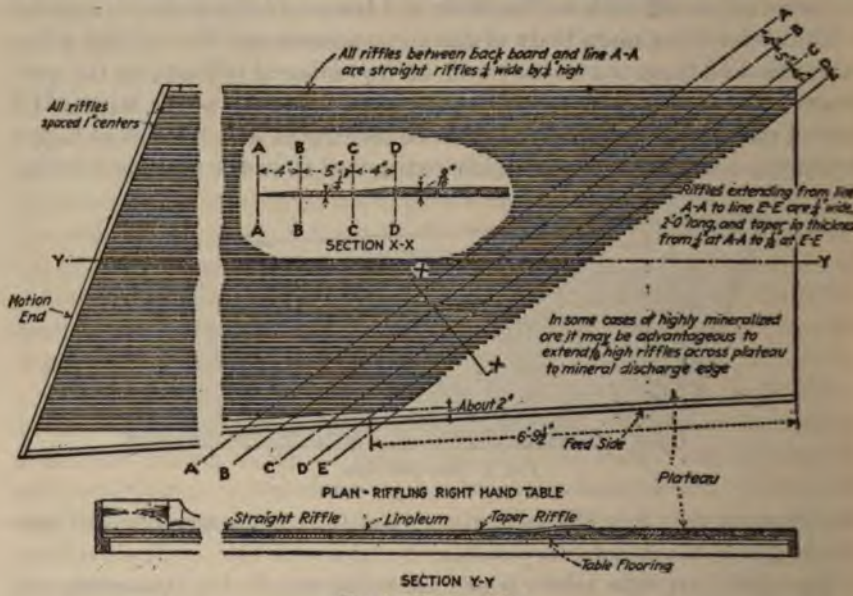
All riffles between back board and line A-A are straight riffles ¼" wide by ¼" high
All riffles spaced 1" centers
A B C D
4" 5" 4"
SECTION X-X
Riffles extending from line A-A to line E-E are ¼" wide, 2'-0" long, and taper in thickness from ¼" at A-A to ⅛" at E-E
Motion End
In some cases of highly mineralized ore it may be advantageous to extend ⅛" high riffles across plateau to mineral discharge edge
About 2"
6'-5½"
Feed Side
Plateau
PLAN - RIFFLING RIGHT HAND TABLE
Straight Riffle
Linoleum
Taper Riffle
Table Flooring
SECTION Y-Y

FIG. 3.—Deister riffle.

the standard table. Tests in the Hunter mill at Mullan, Idaho, show increase in weight and assay of the concentrates over those of a standard Wilfley table. The concentrates are spread out in a wider band, less water is required and it is claimed that the capacity of the table is increased 100 per cent. by this device.

The Franz Concentrating Table,[2] which is used in the Cœur d'Alene district of Idaho, differs from a Wilfley table in having the mechanism at the concentrates end and in discharging the concentrates and middlings through slots in the table instead of over the edge. The most important feature of this table, however, is the flexible or hinged deck, which allows

[1] H. M. Ingalls, *Min. Eng. World*, **40**, 778 (1914); *Eng. Min. Jour.*, **98**, 170 (1914).
[2] *Eng. Min. Jour.*, **97**, 1294 (1914).

the concentrates end of the table to be given a steeper slope in a line parallel to the motion of the table than the rest of the table and thus force the concentrates to travel up an incline before they can be discharged. The line of the hinge or joint is parallel to the concentrates end, and since the feed side of the table is much shorter than the tailings side, this line runs diagonally from the feed side to the tailings side.

The Isbell Concentrating Table[1] is a riffled table for which is claimed a high capacity and ability to treat unclassified ore and to make a separation of more than two minerals in one operation. The table is duplex in construction. Feed is introduced at the head end of each deck and moves along the length of the deck to the tail. Each deck really consists of two planes sloping downward slightly from a ridge or gable extending along the longitudinal center line. Wash water is also fed along this center line. Each sloping plane has riffles which extend diagonally from the sides of the deck toward the center ridge. Thus the riffles direct the concentrates uphill toward the ridge or center line of the table, while the wash water washes the gangue downhill across the tops of the riffles and toward the sides of the deck. At suitable places along the center ridge "cut outs" or discharge pipes are placed for the concentrates. In each of these pipes is a rising current of wash water which acts as a classifying element and permits only the heaviest material to pass down the pipe, while lighter grains are washed back on the table.

The Riffle Table Practice in Australia has been discussed by W. Shellshear,[2] who states that the linoleum top Wilfley table and the full-length riffle tables of the Card type are about equally favored. Most table tops are now made with the grooves cut in wooden decks, although linoleum is considered to be the better dressing surface. The advantages of linoleum may be retained if sheets of it are used thick enough to allow grooves to be cut directly in it. Full-length riffles are claimed to give a better division line between concentrates and middlings. Also full-length riffles are coming into favor and are replacing belt vanners on fine material. On these fine tables the speed and length of stroke are changed, and also instead of having the lower side of the riffle groove vertical, as for coarse material, it is made flatter so as to prevent too big a scouring of the fine material in the grooves by the wash water. The Weir-Merideth single-toggle head motion is displacing the Wilfley double toggle, owing to its lower cost of upkeep and less liability to get out of order. Hickory springs are in general use for supporting the table top and the tendency is to do away with the side tilting gear, the hickory springs being bolted direct to angle-iron brackets set on concrete. In

[1] *Eng. Min. Jour.*, **98**, 73 (1914); *Met. Chem. Eng.*, **12**, 601 (1914).
[2] *Min. Eng. Rev. Austral.*, Dec., 1913; *Min. Eng. World*, **40**, 330 (1914); *Min. Mag.*, **10**, 145 (1914).

some places the feed box at the corner of the table has been abolished and the feed is run in at right angles to the table, the feed launder being widened gradually to about 18 in. and the feed distributed across the face of the launder by means of riffles, a piece of balata belt on the side of the table preventing wear where the feed drops on it. This method prevents too great a scouring of the feed at the head end of the table. Better results are claimed where the capacity is low and the feed unclassified. At Broken Hill the average capacity is 0.5 to 0.8 ton per hr. per table. The advantage claimed for unclassified feed is that the trouble of the classifier is eliminated, water is reduced and the coarse material tends to protect and save the fine concentrates. (This is contrary to the conclusions of Richards and others from experiments on table feed.)

A large middling product is usually made and this middling product from three or four tables is cleaned up on one final table. To prevent loss of sulphides which may float across the table, attention is now being turned to the reduction of aeration of pulp and wash water. This aeration may come through the use of centrifugal pumps and other machines which agitate the water in contact with air.

Tables vs. Vanners.—In commenting on the use of two Wilfley tables and 30 Isbell vanners, Caetani[1] states that although in general he is opposed to vanners, yet he favored them in the new Plymouth mill for the following reasons: (1) The gangue is largely slate, which breaks into flakes which are easily washed into the tailings. (2) The quartz is light and large grains are easily washed into the tailings. (3) The ore contains a large percentage of colloidal slime which tends to keep the sand in suspension. (4) The pyrite occurs in crystals and bunches which break free from gangue and reduce the included grain middling product. (5) The middlings of a Wilfley table consist chiefly of small particles of free pyrite which are washed into the gangue. (6) The ore contains considerable arsenopyrite which is a little heavier than the pyrite. (7) The percentage of concentrates in the ore is only 1.8 per cent. and a Wilfley table would be able to make only a narrow streak of concentrates and would have to make a middlings band which would go back to the classifier. Although the vanner allows some gangue to go into the concentrates, still the concentrates are cleaner than those which would be obtained from any other table unless both concentrates and middlings of these tables be retreated on secondary machines.

Round Tables.—A very comprehensive and valuable paper has been written by A. Crowfoot,[2] covering the detailed results of the experimental work in the development of the practice in round-table work at Great

[1] *Min. Sci. Press*, **109**, 670 (1914).
[2] *Bull. Amer. Inst. Min. Eng.*, **92**, p. 1931, August, 1914.

Falls, Montana, and including also a short history of the round table and the development in other districts, especially at Lake Superior. The experimental work dealt with full-size tables and included investigations on slope, amount of solids in feed pulp, wash water, speed, feeding devices, material of surface, character of surface (rough or smooth), and shape of table (conical or conoidal). It is impossible within the limits of this review to give even a summary of these tests, and the reader is advised to consult the original article.

Amalgamation

The past year has seen still further inroads of cyaniding upon amalgamation. The Presidio silver mill at Shafter, Texas, which hitherto has used stamps and pan amalgamation, now uses fine crushing in stamps and pebble mills followed by cyaniding.[1] The Waihi Gold Mining Co., in New Zealand, used stamps, tube mills, amalgamation and cyaniding up to July, 1913, but on that date discarded amalgamation.[2]

Milling gold quartz ores in Colombia by stamps and arrastras is characterized by very little use of amalgamation, except in cleaning up some small residues. The gold from both oxide and sulphide ores is caught on rough-bottom launders and blanket tables. These are cleaned up periodically and the final separation of the gold made by bateas. The batea tailings are amalgamated.[3]

In the two big mills of the Porcupine district of Canada, the Dome and the Hollinger, treating ores similar in character but differing in grade, the former uses amalgamation in water followed by cyaniding, while the latter crushes in cyanide solution without amalgamation. The differences in the results obtained from these two mills are not great enough to show a distinct gain for either system.[4]

Where plate amalgamation is practised in cyanide solution, difficulties are frequently encountered with hard amalgam and the plates are eaten away by the solution. J. Randall[5] reports that he has avoided these troubles by using mercury riffles charged with sodium amalgam.

The Liberty Bell mill in Colorado has used plate amalgamation in cyanide solution successfully for 8 years.[6] Plates are placed after the stamps which have 12-mesh screens and after the tube mills which grind so that 90 per cent. of the product passes through 80 mesh. The plates are cold-rolled annealed electrolytic copper weighing about 7 lb. per ft.

[1] *Min. Sci. Press*, **109**, 643 (1914).
[2] *Min. Sci. Press*, **109**, 180 (1914).
[3] R. W. Perry, *Eng. Min. Jour.*, **97**, 889 (1914).
[4] N. Cunningham, *Min. Sci. Press*, **109**, 19 (1914).
[5] *Met. Chem. Eng.*, **12**, 248 (1914); *Jour. Chem. Met. Min. Soc. So. Afr.*, **15**, 62 (1914); *Can. Min. Jour.*, **35**, 300 (1914).
[6] C. L. Peck, *Eng. Min. Jour.*, **98**, 335 (1914).

and are laid on two or more thicknesses of tarred felt and secured to the table by brass screws. They are then scoured clean with lumps of cyanide, sprinkled with mercury, rubbed with brooms until mirror bright and finally about ½ oz. of gold-silver amalgam per sq. ft. is brushed evenly over the surface, which makes the plates efficient from the start. The stamp plates each have an area of 32 sq. ft. and are cleaned all over with whisk brooms every 8 hr. and the upper half of each plate every 4 hr. The bottom half of each plate is scraped once a day, using cabinetmaker's scrapers with 4-in. blade which is filed square each time used. The principal clean-up occupies 1 hr. for 16 plates. A half hour later the plates are sprinkled with mercury at the lip of the mortar and at hourly intervals thereafter. The plates are run saturated with mercury so that "points" of mercury are kept hanging at the lower edge without dropping off.

The tube mill tables each have four plates in series with 1-in. drop between. The proportion of silver in the amalgam is greater at this point, which gives more trouble in keeping the plates in good condition. Bare spots tend to form and spread over the two lower plates, the plates become dark and dry and refuse to take mercury and mercury goes into solution. To overcome these difficulties the plates are all scraped with steel each 8-hr. shift. All movable amalgam is removed and the plates then well wetted with mercury, using about 6 to 10 oz. for each of the eight tables. This is rubbed in until the amalgam formed is smooth and plastic. All the tube mill plates are dressed at the 4-hr. interval between cleanings.

Unequal dissolution of the plates tend to render them rough. Frequent scraping rectifies this. Alkaline solutions tend to harden amalgam, which necessitates frequent clean-ups, sprinkling and dressing. Where plates are run saturated with mercury, closer attention is required for the mercury traps following the plates. Mercury does not flour or sicken in cyanide solution. The total consumption of mercury in this mill is about 0.2 oz. per ton of ore. The cyanide solution passing over the plates is heated to a temperature of about 70° F. The life of the plates varies from 3 months and 7 days to 7 months and 18 days, depending on conditions and on the positions of the plates. Precipitation of silver and other metals and compounds from solution and their replacement in solution by the copper of the plates (and mercury in the amalgam) is the chief factor in plate destruction, with the increased dissolving power due to higher temperature second. No deleterious effect of the plates on cyanide solutions has been observed. When amalgamation in water with no tube mills was used, the recovery

by amalgamation was 64.6 per cent. of the gold and 4.16 per cent. of the silver. With amalgamation in cyanide solution at ordinary temperatures and using tube mills, the recoveries were 57.3 per cent. of the gold and 8.08 per cent. of the silver. Heating the solution increases the silver recovery to 11.30 per cent.

The experience at the New Plymouth Mill with amalgamation of a typical California gold ore in a Hardinge mill has not been entirely satisfactory.[1] At the outset only amalgamated plates were used, but it was found that some of the coarse gold was not sufficiently brightened to be caught by mercury. By feeding mercury into the Hardinge mills the amalgamation became complete, but the amalgam was found to form a soft pasty mass in which the coarse gold was ground fine and this mass built up in the crevices of the pebble mill lining. When no more mercury was fed the amalgam became hard and was discharged from the mill and built up in thick layers at the discharge opening. The loss of mercury by flouring in the mill was very high. At present an amalgamating device is being installed to coat the coarse gold with mercury so that it will be caught on the plates.

Magnetic and Electrostatic Separation

The new No. 4 magnetic separating mill of the Witherbee Sherman Co. at Mineville, N. Y.,[2] follows in general the scheme of Nos. 1, 2 and 3 mills,[3] although treating magnetite ore of a lower grade and of a little different character. Trommels are used instead of stationary inclined screens, and all the Ball-Norton separators treating material coarser than 20 mesh make a middling product in addition to concentrates and tailings and these middlings are recrushed in rolls and go back to the trommels.

In the Huff electrostatic plant at Midvale, Utah, which treats the zinc-iron middlings from the wet concentrating plant, the material is first dried and sized on 16-, 40-, 60- and 100-mesh Newaygo screens. The oversize of 16 mesh goes back to the wet mill, while the four undersizes go to separate Huff units, each unit consisting of roughing and finishing machines which make a finished pyrite product, a finished zinc product and a middling product which goes back to the Newaygo screens. One of the units is a new toboggan type of separator. Bare metal electrodes have ben substituted for wood, formerly used, and show a much longer life.[4]

[1] G. Caetani, *Min. Sci. Press*, **109**, 670 (1914).
[2] J. S. Pellett, *Eng. Min. Jour.*, **97**, 549 (1914). H. Comstock, *Iron Tr. Rev.*, **55**, 252 (1914).
[3] Richards, Ore Dressing, Vol. 4, p. 1820. Mineral Industry, **21**, 837.
[4] H. A. Wentworth, *Bull. Amer. Inst. Min. Eng.*, **92**, p. 2217, August, 1914.

Pneumatic Concentration

A dry concentrating plant is reported to be working successfully in the Yellow Pine district of Nevada, treating oxidized ores of lead and zinc where water is scarce and the ore is dry when mined.[1] The ore is crushed through 8 mesh by breaker and rolls and fed directly to the Stebbins dry concentrating table. This table is 3 by 9½ ft. and resembles the Wilfley table in its action, but instead of using water to keep the bed mobile, it uses a constant current of air, issuing through the perforated riffles. The riffles are ¼ in. wide and the perforations are on the downward side close to the table surface, so that the air forms an air cushion underneath the ore between the riffles and thus stratifies the material and the lighter part works down over the tops of the riffles while the heavier part is progressed longitudinally exactly as on the Wilfley table. A dust hood with suction fan removes dust. On a feed containing 15 to 20 per cent. lead, 20 per cent. zinc and 4.5 oz. silver per ton, the table makes concentrates averaging 55 to 65 per cent. lead, 4 per cent. zinc and 4.5 oz. silver, and tailings averaging 3.5 per cent. lead, 23 per cent. zinc and 4.5 oz. silver.

The Plumb air jig which was described last year is now reported to have been developed to the point where it makes a clean separation on unsized feed, and preliminary sizing is therefore no longer required.[2]

A detailed report of the results of a satisfactory test on a lot of brown iron ore from Waukon, Iowa, by the Goltra process has been made by W. B. Phillips.[3] This is really a combined magnetic and pneumatic process. In the first step the ore is treated in a revolving cylindrical drier at a temperature of 200° to 300° F. The heat is applied directly by a blast of ignited pulverized coal. A strong draft is provided through the drier by a suction fan. In this step the heat removes the moisture from the ore and the air current removes the fine sand, clay, earth, etc. The next step is sizing with ¾-, ½- and 1/20-in. screens and hand picking the material coarser than ¾ in. and rejecting material finer than 1/20 in. In the third step the material between ¾ and ½ in., together with the residue from hand picking over ¾ in., is treated in a second cylinder just like the first except that the temperature is about 1000° F. Dust is removed as before. The calcined product is sized on ½-in. screens. The oversize is cooled and hand picked. The undersize is put hot into a tight cylinder and sprayed with crude petroleum to reduce the iron partly to magnetic oxide. This magnetized material is sized on ¼- and 1/16-in. screens and each size is separated by Ball-Norton magnets.

[1] F. A. Hale, Jr., *Eng. Min. Jour.*, **97**, 1083 (1914).
[2] *Met. Chem. Eng.*, **12**, 555 (1914).
[3] *Iron Age*, **94**, 1148 (1914).

Flotation Processes

Important developments in litigation and in the extension of the use of the various flotation processes on lead, zinc and copper ores all over the United States have taken place during the past year. The new Callow flotation process is becoming a favorite in certain parts of the country, and some mills are already making a separation of galena from blende by selective flotation. The economies resulting from flotation are also being appreciated more fully. For these reasons a separate chapter is devoted to this process immediately following this chapter to which the reader is referred.

Accessory Apparatus

For conveying belts Caetani[1] states that the troughing idlers should be tilted forward so that the belt will center itself and they should be spaced 4½ ft. apart instead of 4 ft. Guide idlers should be set as closely as possible to the carrying idlers. First-class belt is the cheapest in the end, and the rubber cover should stretch three and one-half times its original length without breaking. The conveyor may be made as long as 400 ft. unless the slope is very steep. The talc dust on a new belt should be washed off before using. On damp ore containing a large percentage of fines a slope of 22½° is perfectly safe, although rounded lumps of ore will start to roll on a belt sloping 20°. In Australia a slope as high as 28° is used in one mill. The best type of tail pulley is the Boss rimless pulley, which has a face consisting of a series of rib-shaped spokes like a paddle wheel held on a very large conical hub. This prevents lumps of ore from injuring the belt by getting pinched between the belt and the face of a pulley having a solid rim. Long and steep belts should have a head pulley at least 42 in. in diam. lagged with rubber belting to prevent slipping and to allow a looser belt. Automatic distributing trippers should not move at a speed greater than 10 ft. per min. so as not to cause too great a shock when reversing.

For belt elevator difficulties Caetani suggests the following remedies: (1) *Elevator head pulley gets loose.* Use extra heavy shaft, 4 7/16 in. for 16-in. belts 30 in. center to center, and use heavy pulley with split hub and key resting in short keyway. Use two set screws on key and two set screws on shaft. (2) *Belt slips on head pulley.* Lag pulley with 4-ply rubber belting, using two strips of belting touching each other along crown line so that pulley will remain true. (3) *Gear troubles.* Drive by belt either direct or through countershaft. (4) *Spilling at discharge.* Build the receiver so that the edge of the splitter is on a line drawn from

[1] *Min. Sci. Press*, **109**, 670 (1914).

the center of the head pulley at an angle of 55° from the horizontal. (5) *Sand sticks in bucket.* Drill three 3/16-in. holes through bottom of each bucket. (6) *Belt splice breaks.* Use Holtite or Jackson lacing which will outlive any belt. (7) *Belt wears, due to strain.* Use light buckets. No. 10 gauge Salem buckets are strong enough for material finer than 5 mm. It is immaterial where fine sand pulp is fed to the elevator, but coarse material must always be fed directly into the buckets and as gently as possible. (8) *Belt runs off pulley.* Use heavy crown. Washers mentioned in (9) also help remedy this. The belt should be at least 1 in. wider than buckets. (9) *Wear under buckets.* Use pure rubber washers ¼ in. thick, 1½ in. diam. with ¼-in. hole in center. These are inserted on each bolt between the bucket and the belt and are compressed to about 3/16 in. (10) *Rocks wedging between pulley and belt.* Always use Boss rimless pulleys for boot pulley when elevating stuff coarser than 3 mm. (11) *Bearings for elevator boot shaft.* These should be of a solid closed pattern. (12) *Elevator buckets.* Large buckets should always have two rows of bolts, and not less than seven 5/16-in. bolts should be used.

In Australian practice[1] belt elevators are used on crude ore 1½-in size to 0 and for water and fine feed in the form of pulp. The feed should be delivered into the buckets from the front. The housing is best inclined at 80° and made two and one-half to three times the width of the elevator belt. The buckets should discharge at least 4 ft. above the lip and 6 to 7 ft. is the usual practice. Boots should be above the ground and have 6-in. bottom plug; in elevating coarse ore it is inadvisable to close in the bottom of the elevator with a boot. Shafts should be heavy, 4 in. diam., and shields 16 in. in diam. used to prevent grit from entering boxes. Pulleys are 27 in. diam. in best practice, crowned ¼ in., with face 3 or 4 in. wider than the belt. Direct belt drives are sometimes used, but usually gearing is advisable with a gear ratio of 4 to 1. Rope drives are very satisfactory. The minimum speed is 250 ft. per min., but average speed at Broken Hill is 350 ft. per min. and 500 ft. has been used successfully. Wide buckets exert too much leverage on the belts and bolts and it is better to use 10-in. buckets staggered rather than 14-in. buckets on a 16-in. belt. For fine pulp about three ¼-in. holes are placed in the bottom to facilitate delivery. Experiments at Broken Hill show that the efficiency of a well-designed elevator is 30 per cent. The height of lift of a single elevator should not be over 50 ft.

In a practical article on the installation and running of belt elevators A. M. Merton[2] deals with the subject according to the following headings:

[1] W. Shellshear, *Mex. Min. Jour.*, **18**, 21 (1914). From *Austral. Min. Eng. Rev.*
[2] *Min. Eng. World*, **40**, 1067 (1914); **41**, 11 (1914).

size of buckets, slope, method of feeding, speed, buckets, belt, pulleys, housing and power consumed.

Centrifugal pumps lifting sandy pulp usually show rapid wear of the shaft where it enters the stuffing box due to grit, unless water is fed constantly at this point to wash away the grit. In one case where the use of water was impracticable hard grease forced constantly under pressure through the stuffing box accomplished the same purpose.[1]

Air lifts for raising pulp have the disadvantage that the submergence must be provided for and they do not accommodate themselves to wide ranges of capacity. The depth of submergence should be at least 45 per cent. of the sum of the submergence plus height of lift. The theoretical air pressure necessary is 0.433 times the specific gravity of the pulp times the depth of submergence, and 3 or 4 lb. should be added for friction. The efficiency of the apparatus is about 35 per cent. in mill work. The following table indicates that at least 2.5 cu. ft. of free air should be provided for each cu. ft. of pulp.[2]

Diameter Rising Main, In.	Well Diameter, In.	Diameter Air Pipe, In.	Pulp Capacity, Cu. Ft. per Min.	Free Air Required, Cu. Ft. per Min.
1	2½	⅜	1.25	4
1½	3	⅝	3.50	11
2	4	½	6.60	20
2½	4	⅝	10.00	30
3	5	¾	15.00	50

Regarding launders, H. E. West[3] recommends a minimum grade of 10 per cent. for stamp mill pulp through a 3-mesh screen and having a water-to-sand ratio of 6 to 1. W. A. Caldecott[4] has published a curve based on empirical formulæ derived from actual observations. This curve is for sand tailings with about 4 per cent. pyrite and containing not over 10 per cent. of material coarser than 60 mesh and carried by various amounts of water. A. V. Zwaluwenburg[5] advises that pipe launders be avoided and that tests be made to determine the necessary amount of fall in order to avoid launder troubles.

Principles, Theory and General Ideas

Progress in ore dressing has been the subject of two papers, one by Dr. Herwegen[6] and the other by W. J. Bartsch.[7] The former deals especially with the treatment of sands and slimes, the high losses which occur in

[1] *Eng. Min. Jour.*, **97**, 1150 (1914); *Jour. Chem. Met. Min. Soc. So. Afr.* **15**, 80 (1914).
[2] A. M. Merton, *Min. Eng. World*, **40**, 469 (1914).
[3] *Eng. Min. Jour.*, **97**, 517 (1914).
[4] *Jour. Chem. Met. Min. Soc. So. Afr.* **14**, 486 (1914).
[5] *Mex. Min. Jour.*, **18**, 348 (1914).
[6] *Metall u. Erz*, **11**, 113 (1914); *Revue des Mines* [V], **6**, 222 (1914); *Min. Jour.*, **104**, 251 (1914).
[7] *Metall u. Erz*, **11**, 185, 242 (1914); *Min. Sci.*, **69**, p. 49, Aug., 1914; *Min. Jour.*, **105**, 506 (1914).

concentrating slimes, the character and effect of colloids, pulp thickening and water clarifying, and flotation processes. The latter is much wider in its scope and deals with general progress, including physical and chemical properties of ores and the application of the various processes of hand sorting, crushing, sizing, classifying, magnetic and electrostatic separation, flotation and amalgamation.

The concentrating of the low-grade iron ores of the Mesabi district has led to extended work on this problem, and the results of tests of 43 separate ores are reported by W. R. Appleby and E. Newton.[1]

In considering table concentration *vs.* flotation A. Schwarz[2] points out that table concentration should not be entirely discarded for the following reasons: (1) It saves very fine crushing; (2) it is cheaper; (3) it saves a large percentage of the oxide and carbonate minerals which can not be saved at all by flotation; (4) it makes cleaner concentrates.

The need of systematic testing in milling plants has been discussed by G. E. Collins,[3] including the occurrence of discordant results from tests and the necessity of continuing tests for a considerable time in order to avoid such inconsistent results.

The rates of flow of dry sand of various sizes, shapes, and specific gravities through orifices of different shapes and sizes and under varying heads, has been studied by E. A. Hersam,[4] and formulæ derived for computing the rate under given conditions.

Examples of Practice

This year has seen the starting of at least four important new mills: the National, the Daly West, the Timber Butte and the Mary Murphy. The first is a copper mill, while the other three treat ores that are more or less complex sulphides of lead, zinc and iron.

The New National copper mill at Mullan, Idaho, is of particular interest in that it is the only mill in the Cœur d'Alene district treating copper ore and is the first mill to use the Callow pneumatic flotation process.[5] The ore consists of a clean, hard, gray-to-white quartzite[6] with finely disseminated chalcopyrite, chalcocite, bornite and pyrite. The ore is so hard that lumps of ore are used instead of flints in the Hardinge mills. The mill itself has a capacity of 500 tons per 24 hr. The coarse-crushing section has a capacity of 500 tons in 8 hr. The total steel consumption in crushing this hard ore is placed at from 0.7 to 0.8 lb. of steel per ton of ore. The ore treated averages 1.5 per cent. copper with

[1] *Bull.* No. 2, Minn. School of Mines Expt. Sta., 1913.
[2] *Eng. Min. Jour.*, **98**, 317 (1914).
[3] *Colo. Sci. Soc.*, **10**, 431 (1914); *Min. Sci.*, **69**, p. 55, June, 1914; *Mex. Min. Jour.*, **18**, 354 (1914); *Met. Chem. Eng.*, **12**, 243 (1914).
[4] *Jour. Frank. Inst.*, **177**, 419 (1914).
[5] E. S. Bardwell, Private communication.

silver values equal to the copper. The gold content is very low. The ratio of concentration is about 15 to 1. The total extraction is 85 or 90 per cent., 30 per cent. by the tables and 55 per cent. by flotation. The feed to flotation averages 0.8 per cent. copper. Mill concentrates run between 17 and 20 per cent. copper. The total mill tailings carry about 0.2 per cent. copper, while the flotation tailings average 0.14 per cent.

The ore from the mine is trammed to (1).

1. Mill bin, 1200 tons capacity. By gate and belt conveyor to (2).
2. One 15 by 30-in. Blake breaker, crushing to 3 in. The breaker attendant picks out approximately equiaxial pieces of ore from 3 to 8 in. diam. which go by chute, conveyor and spout to Hardinge mills to take the place of flint pebbles. To (3).
3. Belt conveyor provided with magnetic drum at discharge end for removing drill points, etc. To (4).
4. One 48-in. Symons crusher. The crusher discs revolve in opposite directions at speeds of 100 and 200 r.p.m. respectively. It crushes 60 to 70 tons per hr. from 3 in. to ¾ in. Difficulty has been caused by steel getting into crusher due to failure of attendant to throw the switch magnetizing the picking magnet. Product by two 24-in. elevators to (5).
5. Two Symons (Ferraris type) shaking screens, each 48 by 60 in. with ⅜-in. round holes, screening dry. Oversize to (7); undersize to (6).
6. Two bins, each holding 500 tons. By gates and feeders to (8).
7. Two sets of 48 by 16-in. rolls. To (5).
8. Four 8-ft. by 20-in. Hardinge mills crushing to 30 mesh. To (9).
9. Four duplex Callow belt screens, 30 mesh. Oversize by elevators to (8); undersize by two revolving distributors to (10).
10. Eight No. 6 Wilfley tables and eight No. 4 Deister tables, used as roughers. Middlings by elevator and sloughing off tank to (11); tailings to (14).
11. One duplex Callow belt screen, 60 mesh. Oversize to (12); undersize to (13).
12. Two No. 6 Wilfley tables. Concentrates to (22); middlings by elevator and sloughing off tank to (11); tailings to (14).
13. Two No. 4 Deister tables. Products like (12).
14. Two drag-type classifiers. Sand to (15); slime to (17).
15. Two Hardinge mills 8 ft. by 48 in., crushing to 60 mesh. To (16).
16. Two duplex Callow belt screens, 60 mesh. Oversize to (15); undersize to (17).
17. Two Dorr thickeners, 30 ft. diam., 10 ft. deep. Pulp thickened to 1½ : 1, by distributor to (18); overflow to waste.
18. Two Pachuca tanks. Pulp diluted to 4½ : 1 receives 0.13 lb. of pine oil per ton of ore treated in the mill, is agitated with air under 20 lb. pressure and goes by distributor to (19).
19. Eight Callow pneumatic flotation cells used as roughers. Each cell is 4 ft. wide and 12 ft. long and divided into four compartments. The depth is 3 ft. at the upper end and the bottom is of four thicknesses of heavy twilled canvas sloping downward toward the tail 3 in. per ft. The air is forced up through the bottom under a pressure of 8 lb. per sq. in. Concentrates by air lift to (20); tailings to (21).
20. Two Callow pneumatic flotation cells used as cleaners. Concentrates to (22); tailings pumped to (19).
21. Two Dorr thickeners, 30 ft. diam., 8 ft. deep. Thickened pulp to waste; overflow clear water for (18).
22. One Callow tank, 8 ft. diam. Pulp thickened to 1 : 1 to (23); overflow to waste.
23. One 20 by 10-ft. tank with A. Z. agitator. Pulp to (24); overflow to flotation circuit.
24. One 44-in. by 9-ft. Kelly filter press. Cake with 14 to 15 per cent. moisture dried by steam to 6 per cent. and conveyed to concentrates bins; water to waste.

The oil consumption in the Callow process amounts to 8 gal. pine oil daily which costs $0.57 per gal. The total horse-power for the entire flotation operation, including the air for the mixing tanks and the Pohle air lift, is obtained from a 30-hp. motor. One man on each shift looks after the upper and lower Dorr tank floor as well as the flotation floor. The Callow system is treating 493 tons per 24 hr. The total labor cost for the mill is $10.50 per day. The total milling cost is 60 cts. per ton of which 16.6 cts. is for labor. The labor cost for Callow flotation is 2 cts. per ton.

The Timber Butte Mill at Butte, Montana,[1] has a capacity of 450

[1] E. S. Bardwell, Private communication.

tons per 24 hr. treating zinc ore from the Elm Orlu mine. The ore is received in (1).

1. Mill bin, 800 tons. To (2).
2. Shaking grizzlies with 1½-in. spaces. Oversize to (3); undersize to (4).
3. Farrell-Blake breakers, 15 by 30 in., crushing to 3 or 4 in. To (4).
4. Bin. By feeder and elevator to (5).
5. Symons shaking screens with ¾-in. holes. Oversize to (6); undersize to (7).
6. Symons disc crushers crushing to ¾ in. or 1 in. To (7).
7. Two 24-in. belt conveyors. To (8).
8. Bin, 1200 tons. By four automatic feeders to (9).
9. Two 20 by 54-in. Garfield rolls crushing to 2½ mm. By elevator to (10).
10. Four Colorado impact screens, 2½ mm. Oversize to (9); undersize to (11).
11. Eight Wilfley roughing tables. Lead-iron middlings to (12); zinc concentrates to (34); middlings returned to tables; tailings to (13).
12. A 3-compartment Harz jig. Lead-iron concentrates from hutches 1 and 2; zinc concentrates from hutch 3; tailings returned to jig.
13. Akin classifier. Sand to (15); overflow to (14).
14. Dorr thickener. Slime to (24); overflow clear water for mill.
15. Two Hardinge mills grinding to 20 mesh. To (16).
16. Eight James roughing tables. Lead-iron concentrates to (17); zinc concentrates (50 to 52 per cent. zinc) to (34); middlings returned to tables; tailings to (21).
17. Five-spigot Richards classifier. Spigots 1 and 2 to (18); 3 and 4 to (19); 5 to (20); overflow to (34).
18. Two Harz jigs. Lead-iron concentrates to (34); zinc concentrates to (34).
19. Two Wilfley tables. Products like (18).
20. One James table. Products like (18).
21. Akin classifier. Sand to (23); overflow to (22).
22. Dorr thickener. Slime to (24); overflow clear water used in mill.
23. Hardinge mill grinding to 60 or 80 mesh. To (24).
24. Elevator. To (25).
25. Sludge tank. To (26).
26. Minerals Separation flotation machine. Feed 13 to 14 per cent. zinc. Concentrates (46 to 48 per cent. zinc) to (27); tailings (0.7 to 1.3 per cent. zinc) to (31).
27. Minerals Separation machine. Concentrates (50 to 51 per cent. zinc) to (28); tailings by elevator to (29).
28. Eight James tables. Lead-iron concentrates to (17); zinc concentrates (54 to 55 per cent.) to (34); tailings returned to tables.
29. Dorr thickener. Sand to (30); overflow clear water used in mill.
30. Hardinge mill. To (24).
31. Akin classifier. Sand to (32); overflow to waste.
32. Hardinge mill. To (33).
33. Classifier. Spigot to (24); overflow is tailing to waste.
34. Concentrates are separated from water by classifiers, Dorr thickeners and a Kelly filter press.

It will be noted that no tailings are thrown away coarser than about 100 mesh. The mill feed assays 18 to 20 per cent. zinc, 1 per cent. lead, 0.8 per cent. copper, 7 to 8 oz. silver per ton and 20 to 80 cts. gold per ton. The extraction is about 96 per cent. The extraction in the flotation department is about 94 per cent. Mill tailings assay from 0.7 to 2 per cent. zinc. Jig concentrates assay 40 to 48 per cent. zinc, 8 to 12 per cent. iron and 3 to 4 per cent. insoluble. Table concentrates assay about 48 per cent. zinc, 8 per cent. iron and 4.5 per cent. insoluble. Flotation concentrates assay 51 per cent. zinc, 4.2 per cent. iron and 3 to 4 per cent. insoluble. Lead-iron concentrates assay 18 to 28 per cent. zinc, 18 to 22 per cent. iron and 10 to 35 per cent. lead. The mill building is largely reinforced concrete.

The new Daly West Mill at Park City, Utah, will replace the old mill destroyed by fire, which treated a complex galena, blende, pyrite ore.[1] The new mill will have an elaborate jig and table treatment, as before, to make lead concentrates, zinc-iron middlings, zinc concentrates and tailings, but in addition will have the following special features: (1)

[1] F. W. Sherman, *Min. Sci. Press*, **109**, 370 (1914); *Min. Eng. World*, **41**, 252 (1914).

48-in. Symons fine disc crusher after the Blake breaker; (2) magnetized pulley in feed conveyor to remove metallic iron; (3) Blake Dennison weighing conveyor; (4) preliminary screening at 6 mesh, the oversize being jigged to yield lead concentrates to smelter and middlings to be recrushed, and the undersize being deslimed and jigged to remove a lead concentrate before the final screening and classifying by three Akins impact screens and Richards Janney 5-spigot classifier; (5) eight divisions of the product under 6 mesh to go to jigs and tables; (6) thickening tanks for slimes and flotation apparatus with 14 successive agitations for the thickened slime.

The Mary Murphy Mill at Romley, Colorado,[1] has a very difficult problem to treat a complex lead-zinc-iron-copper sulphide ore finely disseminated and carrying free gold. The ore is crushed to $\frac{3}{16}$ in. and that part which is coarser than 1 mm. is treated on jigs and tables. The tailings are reground to 1 mm. in pebble mills and together with the original material finer than 1 mm. are passed over amalgamated plates and carpet tables, classified and finally separated on riffle tables and Monell slime vanners. The zinc-iron middling product from the tables and vanners is treated in a Huff electrostatic plant.

The slime treatment plant at Anaconda is now in full operation,[2] handling 2500 tons of dry slime or 26,350,000 gal. of pulp per 24 hr. from the mill treating 12,500 tons per 24 hr. This slime is 95 per cent. finer than 200 mesh, contains 2.10 per cent. copper and 35 per cent. colloids, and carries 21 per cent. of the total copper in the mill feed. The flow sheet is as follows:

1. 160 Dorr thickeners 28 ft. diam., 3 ft. deep, arranged in batteries, four tanks high. Spigot (2450 tons dry per 24 hr. with 3,296,000 gal. water) to (2); overflow (50 tons dry with 23,054,000 gal. water) used as clear water.
2. Automatic distributor with 20 divisions, each division followed by a second distributor with 20 divisions, or 400 divisions in all. To (3).
3. 400 round table decks, 20 stands of 20 decks each, 19 ft. diam., slope 1¼ in. per ft., fed over 70 per cent. of circumference, washed over 18 per cent. and concentrates removed on 12 per cent., 1 rev. in 4 min., wash water 5,600,000 gal. Concentrates (370 tons dry with 3,600,000 gal. water) by three 6-in. centrifugal pumps (one spare) to (4); middlings (200 tons dry with 1,596,000 gal. water) by two 6-in. centrifugal pumps (one spare) to (2); tailings (2080 tons dry with 5,296,000 gal. water) to waste.
4. Five Dorr thickening tanks, 50 ft. diam., 12 ft. deep. Spigot product (370 tons dry with 84,100 gal. water) to (5); overflow clean water (3,515,900 gal.) to be used again.
5. Three 12 by 12-ft. Oliver filters (one spare). Cake (370 tons with 46,700 gal. water) conveyed to railroad cars; water (37,400 gal.) to waste.

The concentrates assay 7 per cent. copper and the cost of recovering them by the slimes plant amounts to ¾ cts. for each pound of copper recovered. The tailings, containing 1.1 per cent. copper, go to Minerals Separation flotation where they are reduced to 0.1 or 0.2 per cent., thus making a total recovery of copper by milling of about 95 per cent.

Messrs. Laist and Wiggin have published the details of the experi-

[1] H. C. Parmelee, *Met. Chem. Eng.*, **12**, 21, 157, 217, 243 (1914); *Metall u. Erz*, **11**, 95 (1914).
[2] F. Laist and A. E. Wiggin, *Bull. Amer. Inst. Min. Eng.*, **92**, p. 2201, August, 1914. W. R. Ingalls, *Eng. Min. Jour.*, **97**, 937 (1914); *Metall u. Erz*, **11**, 388 (1914).

mental work made in the development of this slime plant, including also the effect of temperature and chemicals in settling the slime.

The 1200-ton mill of the American Zinc Co. at Joplin, Missouri, with its jigging plant, sand plant and slime plants, stands out in sharp contrast to the old jigging mills which sent sand and slimes to waste, and is an excellent example of the progress in milling in this district. In the sand plant two grades of sand are made for recovery of lead and zinc concentrates by tables. In the slime plant the material treated is finer than 200 mesh and carries about 5.5 per cent. zinc. It is first thickened in ten cone classifiers and then treated on four James tables and one Wilfley table. The tailings assay about 1.5 per cent. zinc.[1]

For the treatment of the old tailings of the Silver Lake lead mill at Silverton, Colorado, a 500-ton plant is being erected. The Wilfley multiple-deck tilting slime concentrators will be a feature of the equipment. These old tailings average about $3 per ton.[2]

Treatment of Coal

Although the washing of coal is on the increase, there have been no marked developments in methods or apparatus during the past year.

Investigations.—Jungst[3] has continued his investigations on the jigging of fine coal, including the detrimental effect of sludge and the way to secure the best results. (See Mineral Industry, **22**, 854. In general it may be stated that every coal washer should test out the impurities and their specific gravities in each size of coal handled, in order to determine the proper method of treatment.

The experience of the Keystone collieries has indicated that with their particular grade of coal it is only the very finest sludge material (0.01 in. or finer) that runs high in sulphur and ash, and that therefore the coarse sludge can be added to the washed coal without harm and that a preliminary dust chamber to remove this coarse and fine sludge would be a disadvantage in their case.[4]

The Delamater formulæ for coal washing efficiency[5] have been further elaborated and discussed by their author and by J. B. de Hart,[6] and in connection with the Hancock chart additional formulæ are proposed for comparing the work of actual washing with standards obtained by the float and sink test methods.

For practical use in connection with the standard float and sink apparatus, Delamater has prepared a chart showing by curves the weights

[1] E. H. Leslie, *Min. Sci. Press*, **108**, 840 (1914).
[2] *Met. Chem. Eng.*, **12**, 11 (1914).
[3] *Glückauf*, **50**, 6, 913 (1914).
[4] E. C. Taylor, *Coal Age*, **5**, 28 (1914).
[5] Mineral Industry, **21**, p. 990.
[6] *Coal Age*, **5**, 723, 979 (1914).

and percentages of water and zinc chloride required to give enough solution of any desired specific gravity between 1 and 1.5 to make a test in the apparatus.

The applicability of the Huff electrostatic process to the cleaning of fine sizes of anthracite has been proved in an experimental plant, but no commercial installations are reported as yet.[1]

Apparatus.—The design and installation of screens and picking tables have been considered by M. L. Hyde[2] in connection with the general details of construction of colliery plants.

A new jig for anthracite is of the movable sieve type, but instead of having only an up and down motion it has a combination of up and down with back and forth motion through the medium of four eccentrics, which is claimed to increase the rate of separation and thus the capacity of the jig.[3]

The installation of centrifugal driers for dewatering coal after washing is noted.[4]

Anthracite Practice.—The new Loomis anthracite breaker of the Delaware, Lackawanna and Western Co. in Pennsylvania will be of steel and reinforced concrete throughout, with glass siding of ¼-in. wire glass.[5]

Bituminous Practice.—A new washer for lignite has been completed by the I. & S. C. M. Co. at Issaquah, Washington.[6] The coal is sized on 4-, 2.5- and 0.75- in. screens. That coarser than 2.5 in. is hand picked; that between 2.5 and 0.75 in. is jigged on a Shannon jig with one sieve; that through 0.75 in. is jigged on a three-sieve Foust jig. Washed coal from the Shannon jig is sprayed with water to remove fines which go to the Foust jig. The Foust jig product is also sprayed and screened into pea (through 0.75 on 0.25 in.) and buckwheat (through 0.25 on 0.125 in.).

The Friedrich Heinrich crushing, picking and jigging plant at Lintfort, handling 4000 tons of bituminous coal in 16 hr., has been described by P. Büssing.[7]

Two model screening and picking plants for bituminous coal have been described by R. G. Read.[8]

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[5] F. K. Brewster, *Coal Age*, **6**, 816 (1914).
[6] L. S. Richards, *Coal Age*, **5**, 600 (1914).
[7] *Glückauf*, **50**, 285 (1914).
[8] *Coal Age*, **6**, 255 (1914).

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THE FLOTATION CONCENTRATION OF ORES

[EDITOR'S NOTE.—In view of the widespread interest in the subject of Flotation, it was thought desirable to include in this volume as detailed information on the subject as could be obtained. On account of pending litigation, not as much information is obtainable as might be desired. The following material is the result of a series of letters to the various companies concerned, and outlines the situation as it stands at present so far as could be learned. Until decisions are handed down in the cases at present undecided, the various operating companies can not be classified beyond the two general divisions, those operating under Minerals Separation license, and those operating without a license.]

The success which has attended the use of flotation on diverse ores in different parts of the world, has aroused wide interest in the flotation processes and their application. Flotation is a general method of separating sulphide minerals from gangue. It has been for the purpose of making this separation that most flotation apparatus has been developed and most installations made.

The forces which give rise to flotation are believed to be molecular forces, and their peculiar activities are evidenced as follows:

First.—Minerals of non-metallic aspect and most non-sulphides are more easily wetted by water than are sulphide minerals and some few other minerals of metallic aspect, as graphite.

Second.—This difference in tendency to become wetted by water can be accentuated by the use of certain substances, of which the oils form a large group.

Third.—When this difference in tendency to become wetted by water has been accentuated by the proper use of such substances in minute proportions, small particles of sulphide minerals have a strong tendency to be held at gas-water surfaces.

This tendency is usually so strong that persistent and stable froths can be formed in large quantities composed almost entirely of sulphide minerals with water forming the bubble walls. These phenomena are generally considered as resulting from "surface tension" forces. By surface tension forces are meant the molecular forces acting at air-water surfaces which give rise to a number of phenomena, among them the meniscus phenomenon and the skin or membrane effect at an air-water surface.

In view of the erroneously exaggerated importance given to some of

the prior art patents[1] notably that of Carrie J. Everson, it is perhaps well to correct such statements at this time, as their true status has been carefully investigated and made known in sworn statements in the various cases now in the Federal courts.

It has been known for centuries that oils tend to coat metallic particles immersed in water. This was disclosed about 400 B.C. in the writings of Herodotus. The next appearance of this fact in public documents or literature was in a British patent to Haynes in 1860, wherein was disclosed a process for concentrating ores by producing a mortar-like mass of finely ground ore and about 11 per cent. of oily material. From this mass the gangue was washed out by the action of a triturating machine or pug mill. Nothing of any practical value came from this disclosure. Twenty-five years later an American woman, Carrie J. Everson, disclosed an improvement upon this process consisting in the use of acid in connection with the oil, but this process also proved to be of no commercial value. It represented, however, a substantial step forward over anything that had gone before, as it disclosed a new phenomenon, namely, the accentuation by sulphuric acid of the differential tendencies of sulphides and gangue to become wetted by oil and water. The patent was applied for in 1885 and issued in 1886. It describes two methods, in one of which the process is essentially the same as Haynes, except for the addition of acid, and here the amount of oil is 5 per cent. of the ore. The second method disclosed in the Everson patent employs a light oil, such as kerosene, and recommends the use of such a proportion of oil, 17.1 per cent. of the ore, or 342 lb. to the short ton of ore, that the mixture of metalliferous mineral and oil is lighter than the sand or gangue, but heavier than water. The patentee says "that the devices and methods known in the wet separation of ores may be used for separating the metalliferous mineral and gangue, bearing in mind that the sand and metalliferous mineral are merely transposed or their relative positions are reversed." This process has been represented to be a flotation process, but it falls far short of that, since the mixture of oil and metalliferous mineral, being heavier than water, could never reach the surface. It is, however, perfectly feasible to carry off the metalliferous mineral in suspension in exactly the same manner as the sands are carried off in the wet treatment of ores. This process was especially recommended for previous metals, and is reported to have been tried out on one occasion with a silver ore from Fryor Hill, Colorado, and on another occasion with a gold ore from the Eureka and Excelsior mine in Oregon. Probably in both instances enough oil was used to float the sulphides by oil

[1] Concentrating Ores by Flotation, 2d Edition, T. J. Hoover, pp. 4–40.

buoyancy. The publications describing these tests are so indefinite in their disclosures that no exact information is obtainable from them.

Flotation of minerals by oil buoyancy alone was definitely and certainly accomplished by the Elmore processes which appeared about 1900. The use of acid, which had been disclosed by Miss Everson, was availed of. The quantities of oil used were about 100 per cent. of the ore, and on an average there were three successive treatments, each with an amount of oil equal to 100 per cent. of the ore, the oil being recovered, so far as possible, by the use of a centrifugal separator. These Elmore processes were tried out extensively in various parts of the world, but the cost of oil was always found to be prohibitive and the operations were abandoned as uncommercial. They created considerable interest in the metallurgical world, however, and stimulated other inventors to attempt improvements, but none of the improvements became commercial. Variously, these proposed improvements involved blowing air into the mass of oil to make it spongy and add to its buoyancy, or of generating gas chemically therein so as to introduce bubbles of gas into the mass of oil and mineral and thereby increase its buoyancy, or else of using a thin oil which could be wholly recovered by distillation, so as to diminish the consumption of oil and provide for its complete recovery, together with the blowing in of air. The oil proportions in these proposed modifications were from 12.5 per cent. upward, mainly upward.

A further reduction of the oil to about 2 or 3 per cent. on the ore was found to result in a gathering of the mineral particles into pellets when properly agitated, and these pellets could be agglomerated until they were of such size that the gangue mineral could be washed free of them by an up-current of water, the pellets sinking and forming a clean concentrate. These pellets were similar in structure to concrete, the oil taking the place of cement, the sulphide particles taking the place of the sand and rock, though, of course, on a diminutive scale. The oil consumption in this process, which was known as the Cattermole process, was still prohibitive for most ores, and while an attempt was made to operate it commercially, the discovery of the agitation air-froth process at about that time changed the whole course of oil concentration.

It was found while investigating the economic limits of the Cattermole process, but in fact carrying the reduction of oil far below the Cattermole limits, that if the oil used was reduced to a small fraction of 1 per cent. of the weight of ore, and other proper conditions were maintained, a most striking change took place. Instead of the pellets being formed, the mineral came to the surface as a heavy froth, the bubble walls being armored with sulphide mineral, the gangue being left behind, or sinking, and the oil used practically disappearing. This froth

was tenacious and stable and has stood for weeks without altering. The characteristic of this process, which is the agitation air-froth process and which has successfully solved the problem of concentrating metalliferous minerals with all their slimes, is the utilization of bubbles of air for the selection of the metalliferous mineral. The frothing agent, usually, though not necessarily, oil or containing oil, when present in minute proportions, controls the air-bubble formation, and increases the attraction of the air bubbles for the sulphide particles. It gives to the mineral froth which is formed a persistency such that the bubbles will carry the mineral up through the pulp and through the surface of the pulp to form either a mass of quiet froth which will gently overflow the lip of a spitzkasten, or an active ebullient froth such as will carry the mineral over the lip of the apparatus in which the froth is formed. The first method of separation is that by spitzkasten with agitation in a separate vessel. The second method of separation is that by sub-aeration, with air admission at the lower part of a body of liquid and froth delivery above the upper surface of the same body of liquid.

Some time before this discovery was made, it had been found that certain zinc sulphide ores, such as those at Broken Hill, Australia, when treated with hot dilute sulphuric acid solutions, would yield a froth of sulphide mineral. The explanation of this was believed to be that the hot sulphuric acid solution thoroughly cleaned the surfaces of the mineral particles, thus making the surface forces more active and also generating a small amount of hydrogen sulphide at those surfaces which immediately became attached to the particles. The sulphuric acid also generated carbon dioxide from carbonates in the ore, and the various gases floated the mineral to the surface where it could be separated. The froth thus formed, while similar in appearance to the agitation air-froth, was much more tender, and it easily dropped out the coarser mineral. This process, called the Potter process, formed the basis of important installations in Australia, the largest being that at the Broken Hill Proprietary mine. It is much more efficient, however, if some oil is used with it.

Another process brought out somewhat later was the Elmore Vacuum process, in which gas for floating the sulphides was generated chemically, and the separation was effected under vacuum. This has also had an important application, but on account of its lack of power to treat large quantities of slime, its use has not been extensive.

Another and later process which depends on the same surface tension forces, is the De Bavay process. In this the prepared ore is brought carefully to air-water surfaces and the mineral floats on the water surface and is thereby removed, while the gangue sinks. This is carried out in

cold circuit and large tonnages have been and are now being treated in the Broken Hill district by this method. The so-called Macquisten Tube process is another surface tension flotation process, which has had a limited success. Both of these use oil and acid.

In the agitation air-froth, or Minerals Separation process which has been installed all over the world, slimed sulphide mineral not separable by gravity concentration, offers little or no difficulty; in fact its presence is advantageous. In the application of this process, fine grinding is the rule, for with the danger removed of high losses in slimed mineral, it becomes merely an economic question as to how fine it pays to grind an ore in order to get all the mineral released. This, of course, varies with each ore, and now that the problem is being studied from this angle, it is being found that many ores require very fine grinding to free the last few per cent. of mineral from the gangue. Sometimes particles of ore so small that they can only be clearly distinguished as separate particles under a high-power microscope, will be seen to still have attached to them smaller particles of mineral. In such cases, therefore, the problem becomes a matter of balancing costs against recovery and grade of concentrate; that is, it becomes economic instead of metallurgic.

From the standpoint of the flotation operator, there are two general classes of ores: first, ores that can be worked at normal temperatures, and, second, ores that require hot circuit treatment.

In the first class come practically all of the common copper, silver, lead, and pyritous gold ores, while in the second class come the zinc ores. In working copper ore, it is not so essential to make an exceedingly clean concentrate, that is, a concentrate practically free from gangue, as it is to make a high recovery. In working zinc ore a clean high-grade concentrate is essential. This is due to the different requirements of the smelters of the two metals and to the difference in price of the two metals. The copper smelter can handle at a profit an ore or concentrate sometimes of very low grade, and can successfully handle a large tonnage of diverse ore with a relatively cheap plant and with low tonnage costs. The zinc smelter, on the other hand, is tied to the necessity of making a large capital investment to get a relatively small tonnage capacity, and his tonnage costs are high. It is necessary for him to get an ore or concentrate having a large amount of metal in it, in order to keep his pound costs low. On account of the low price of zinc compared with copper,[1] and the necessity of locating zinc smelters where labor and fuel conditions are favorable, the freight charges against zinc ore and concentrate amount to a large percentage of the returns. This is

[1] This was written before the phenomenal rise in spelter due to the war.

a general statement applicable to normal conditions, not to abnormal world-war conditions.

The effect of this on the flotation operator is that, with a copper ore, he can make an excellent profit from a concentrate that would be of too low a metal content on the basis of zinc-smelter schedules, to pay transportation to the smelter. In fact, it could not be accepted at all. On the other hand, the operator of a zinc property has to ship a zinc concentrate running as high in zinc as possible, which means that he has to eliminate all the gangue possible from his ore or concentrate. While he is, of course, influenced largely by the freight rates against his concentrate, his conditions are nevertheless dominated by the smelter requirements and spelter price, and he must work accordingly.

Clean concentrates with good recovery are usually obtained by using a circuit heated to approximately 120° F. (50° C.) and made acid with sulphuric acid. The most notable examples of installations using this method are at Broken Hill, Australia, and Butte, Montana.

Hot acid treatment was for some time considered the most general method of flotation, and it was believed by operators and experimentalists that an ore which would not yield a froth under these conditions would not float at all. The work on copper ores in America has demonstrated, however, that many ores can be worked most successfully in cold circuit, and that certain minerals of great economic importance, as chalcocite, will work splendidly in cold neutral or alkaline circuit where they will work with great difficulty, if at all, in a hot acid circuit.

In the flotation treatment of zinc ores the kind of oil used, while important, is not so critically important as it is in the treatment of copper ores in neutral or alkaline circuit at normal temperatures. In the latter case the choice of oil or oil mixture may make the difference between success and failure, and no flotation results at all may be had with some oils or an ore that will yield excellent results with other oils. Also, an oil may work successfully in one case and not in another. Many copper ores, however, are easily treated with a number of different oils. In general, the flotation operator on copper ores uses mixtures of coal tar and its derivatives, various wood oils, as turpentine, pine oil, and the wood creosote oils, and a number of the heavier petroleum distillates, and fuel oil. The asphaltum base oils appear to be more useful than the paraffine base oils.

Some copper ores will work best in an acid circuit, and in some cases even a hot acid circuit is necessary to get a good result. Some will not work at all except in a neutral circuit, and some require an alkaline circuit for best results. This is a matter of determination for each ore, and no general rule can at present be laid down as applicable to all

ores. While zinc sulphide is amenable to the agitation air-froth process in cold non-acid circuit, and in some cases a commercial concentrate can be made with a fair recovery, still, in general, it requires hot acid treatment for best commercial results.

Recently a great deal of thought and work have been given to the development of so-called selective flotation, wherein the difference in floatability of different sulphides is taken advantage of to make separations between them. These differences are accentuated by introducing conditions under which one sulphide is more easily floated than another, and then when the first sulphide is recovered, establishing proper conditions to float the second sulphide. This is becoming of increasing economic importance at Broken Hill in the separation of lead from slime tailing and the subsequent making of a slime zinc concentrate.

In America the possibility of making large profits by increasing the recoveries and raising the grade of concentrates at the porphyry copper properties and thereby lowering their pound costs of producing copper, has been of over-shadowing importance to flotation men, and most of the work that has been done here has been on copper ores. At the same time large tonnages of zinc ore are now being treated in Butte and elsewhere by flotation, and such treatment for these ores is firmly established.

It is probable that about 1,000,000 tons of ore was treated in North America during 1914 by the various modifications of the agitation air-froth process. The tonnage to be treated during 1915 will probably be greatly in excess of that.

Flotation Users

The Britannia Mining & Smelting Co., operating a copper mine on Howe Sound, British Columbia, was one of the first concerns in America to use agitation air-froth flotation. In the old mill the ore was passed over a picking belt and the massive sulphide was picked out and shipped direct, and the waste was also picked out. The remainder was then passed through rolls and jigs and finally over tables and vanners, making a total mill recovery of from 55 to 75 per cent. The concentrate produced was siliceous.

Since the introduction of flotation, the tonnage has been greatly increased. After leaving the picking belt the ore passes through jigs and over roughing tables, which take out the coarse mineral. The remainder is re-ground in Hardinge mills and all sent to the flotation machine. A total mill recovery of over 95 per cent. is thereby obtained in the form of basic concentrates. About 38 per cent. of the total copper is taken out on the picking belt in the jigs and on the roughing tables. The rest is taken out by flotation.

At the concentrator of the Silverton Mines, Ltd., near Silverton, in the Slocan district, British Columbia, a lead-zinc-silver ore is being successfully treated, using cold non-acid treatment. Some lead is taken out prior to flotation on tables, and the ore pulp after thickening passes through two selective flotation boxes where a high silver-lead concentrate is made. The tailing from the selective boxes is given further flotation treatment for the making of a zinc concentrate. By this method a high lead-silver recovery is made, and a fair zinc recovery. The cold non-acid treatment for the zinc is so much cheaper than the hot acid treatment, that it pays to make a somewhat lower recovery of the zinc than would otherwise be considered good practice. A combined mill recovery of approximately 87 per cent. of all the mineral values is obtained, however, which, in view of the treatment, is an unusual result.

The Standard Silver Lead Mining Co. at Silverton, British Columbia, has installed an experimental 50-ton machine.

The Cuba Copper Co., which has rejuvenated the old El Cobre mine near Santiago, Cuba, has installed a 600-ton capacity flotation mill and is obtaining very good results. The treatment is in cold neutral and alkaline circuit.

In the United States a number of installations have been made. At Butte, Montana, the Butte and Superior Copper Mining Co. is treating upward of 1000 tons per day of a zinc-silver ore, carrying small amounts of copper and lead. Recoveries have been around 88 and 90 per cent., although for the last quarter of 1914 an 84 per cent. recovery was reported. This installation is not under license from Minerals Separation, Ltd.

The Timber Butte mill, erected by Senator W. A. Clark for treating ore from the Elm Orlu, has been operating since June, 1914. The ore is practically the same as the Butte and Superior ore, and a recovery of upward of 95 per cent. of the zinc is made. The concentrate carries from 4 to 8 per cent. insoluble matter. The Timber Butte mill has a capacity of about 700 tons per day, and has a record for efficiency not reached by any other mill-treating zinc ores. About 75 per cent. of the values in the Elm Orlu ore is released as clean mineral with relatively coarse grinding. The remainder is not released short of very fine grinding. To avoid grinding all of the mineral fine enough to release the last 25 per cent., the ore is stage crushed, stage ground and tabled ahead of flotation. The flotation tails are classified and the coarse sands are further re-ground and passed through the flotation circuit once more.

Senator Clark installed at the old Butte Reduction Works a 50-ton test plant to test out the old copper tailings there. Excellent results were reported.

Both of these installations were made under license from Minerals Separation, Ltd.

At Basin, Montana, M. W. Atwater has installed a 150-ton Minerals Separation plant to work over the old tailings from the Butte and Superior's early mill operations at the Basin Reduction Works. On these tailings a recovery of about 87 per cent. of the total zinc is obtained, in a concentrate assaying around 52 per cent. zinc.

During 1914 the Anaconda Copper Mining Co. carried out extensive flotation tests at their Washoe plant with Minerals Separation and other machines, with highly satisfactory results. They have since entered into a license with Minerals Separation, Ltd., and are going ahead with the installation of the largest flotation plant in the world for treating all of their current mill tailings. The first installation will consist of twenty-four 600-ton capacity machines.

In Colorado the Atlas Mining and Milling Co. has been operating a 125-ton capacity Minerals Separation machine in its mill near Ouray, for the concentration of lead-silver ore. This work is done in cold non-acid circuit. The ore is crushed in stamp batteries and ground in a Hardinge mill. It is then given all-flotation treatment and an 82 per cent. recovery of the silver, and over 90 per cent. recovery of the lead are made, together with a small amount of gold. As the silver is carried very largely by tetrahedrite, it will be seen that this mineral is no longer the bugbear in milling that it formerly was.

At Leadville, Colorado, the Pingrey Mines & Ore Reduction Co. has been operating a 50-ton Minerals Separation test machine on a great variety of ores.

In Utah a number of installations have been made without license from Minerals Separation, Ltd., the most important one being at the Utah Copper Co. mills, where a large tonnage is now being treated by the agitation air-froth method.

In Nevada the Nevada Consolidated has been experimenting on a large scale with the agitation air-froth method with very excellent results. This also is without license from Minerals Separation, Ltd.

In California the Engels Copper Mining Co. has opened up a new mine in Plumas County and has built a 200-ton mill for treating the ores under license from Minerals Separation, Ltd. This plant went into operation early in January, 1915. On account of the fact that the ore contains a large amount of heavy gangue, no commercial results could be obtained by ordinary tabling, and the mill was built for all-flotation treatment. The copper minerals are chalcocite, covellite, bornite, and chalcopyrite, all in a dioritic gangue. Among the gangue minerals magnetite and hornblende are predominant. The ore is crushed and rolled and finished

in a tube mill, and then given flotation treatment in cold neutral and alkaline circuit. A finished concentrate is made in one operation, assaying from 35 to over 40 per cent. copper, and sulphide recoveries are around 90 per cent. or better. The concentrate is dewatered in a rotary drum filter and shipped to Salt Lake City.

During 1914 the Mountain Copper Co. built a 250-ton mill in Shasta County for treating their concentrating ore, but on account of the European war this did not go into operation during the year. The ore is to be picked and jigged and then given flotation treatment under Minerals Separation license. The copper minerals are chalcopyrite and cupriferous pyrite.

In Arizona the Consolidated Arizona Smelting Co. has a 200-ton flotation mill in operation at Humboldt, in which the Minerals Separation process is employed in combination with roughing tables. The table tailing is dewatered and ground in Hardinge mills and is then taken for flotation, which is the final treatment. A total mill recovery of about 93 per cent. is obtained in this way.

The Old Dominion Copper & Mining Co. carried on extensive tests with a 50-ton Minerals Separation machine in its concentrating plant near Globe, Arizona, and then installed a large 16-compartment Minerals Separation machine in their new mill. The ore is a very difficult one, as it contains a large proportion of oxidized material and clayey gangue, but a considerable improvement has been made in their total mill recovery by the use of flotation.

Inspiration Consolidated Copper Co. installed a 50-ton Minerals Separation testing machine in 1913, and carried on an extensive campaign of testing with it. As a result of this work, it built a 500-ton testing unit as a pilot plant for their big mill, and during 1914 carried out extensive tests with various types of crushing and grinding machinery and flotation apparatus. The results of this indicate that flotation, followed by tabling, is best adapted to the treatment of the Inspiration ore. The tables following flotation remove sulphide too coarse to float. The Inspiration company is operating under license from Minerals Separation, Ltd.

At Superior, Arizona, the Magma Copper Co. has installed a 250-ton flotation plant without license from Minerals Separation, Ltd.

The Miami Copper Co. installed flotation without license from Minerals Separation, Ltd., and suit was filed against them for infringement. This suit was heard and argued before Judge Bradford at Wilmington, Delaware, early in 1915, but his decision has not yet been handed down.

The Phelps Dodge Co. took out a license from Minerals Separation,

Ltd., for the Burro Mountain Copper Co., and has been carrying on extensive tests at various of their properties.

In Tennessee the Ducktown Sulphur, Copper & Iron Co. installed and operated a 50-ton testing unit under license from Minerals Separation, Ltd. While excellent recoveries and grade of concentrate were obtained, the company has not gone ahead with any further installation.

Company.	Location.	Ore.	Principal Minerals.
American Zinc Co.	Tennessee	Zinc	Blende.
Anaconda Copper Mining Co.	Montana	Copper, Silver	Enargite, Covellite, Chalcocite, Pyrite.
Arizona Copper Co., Ltd.	Arizona	Copper	Chalcocite.
Atlas Mining & Milling Co.	Colorado	Silver, Lead	Tetrahedrite, Galena.
Beatson Copper Co.	Alaska	Copper	Chalcopyrite.
Britannia Mining & Smelting Co.	British Columbia	Copper	Chalcopyrite, Bornite.
Burro Mountain Copper Co.	New Mexico	Copper	Chalcocite.
Butte Reduction Works	Montana	Copper	Enargite.
Butte & Superior Copper Co.	Montana	Zinc	Argentiferous Blende.
Consolidated Arizona Smelting Co.	Arizona	Copper	Chalcopyrite.
Consolidated Interstate-Callahan Mining Co.	Idaho	Zinc	Blende.
Cuba Copper Co.	Cuba	Copper	Chalcopyrite.
Doe Run Lead Co.	Missouri	Lead	Galena.
Desloge Lead Co.	Missouri	Lead	Galena.
Ducktown I. S. & C. Co., Ltd.	Tennessee	Copper	Chalcopyrite, Cupriferous Pyrite.,
Engels Copper Mining Co.	California	Copper	Chalcopyrite, Chalcocite, Bornite, Covellite.
Federal Lead Mining Co.	Idaho	Silver, Lead, Zinc	Blende, Argentiferous Galena.
Federal Lead Co.	Missouri	Lead	Galena.
Gold Hunter Mining Co.	Idaho	Lead, Zinc, Silver	Blende, Galena.
Greenhill Cleveland Mine	Idaho	Lead, Zinc, Silver	Galena, Blende.
Hercules Mining Co.	Idaho	Lead, Zinc, Silver	Galena, Blende.
M. W. Atwater	Montana	Zinc, Silver	Blende.
Inspiration Consolidated Co.	Arizona	Copper	Chalcocite, Chalcopyrite.
Kennecott Mines Co.	Alaska	Copper	Chalcocite.
Miami Copper Co.	Arizona	Copper	Chalcocite.
Minerals Recovery Co.	Missouri	Zinc	Blende.
Mountain Copper Co.	California	Copper	Chalcopyrite.
Magma Copper Co.	Arizona	Copper	Chalcocite.
National Copper Co.	Idaho	Copper	Chalcopyrite.
National Lead Co.	Missouri	Lead	Galena.
Nevada Cons. Copper Co.	Nevada	Copper	Chalcocite.
Old Dominion Copper Mng. Co.	Arizona	Copper	Chalcopyrite.
Ozark Mining & Smelting Co.	New Mexico	Zinc, Lead	Galena, Blende.
Pingrey Mines & Ore Reduction Co.	Colorado	Lead, Zinc, Silver	Galena, Blende.
Silverton Mines, Ltd.	British Columbia	Silver, Lead, Zinc	Galena, Blende, Argentite.
Silver Lake Mines	Colorado	Silver, Lead	Argentiferous Galena.
Snowstorm Mining Co.	Idaho	Copper	Bornite, Chalcocite, Chalcopyrite.
Standard Silver Lead Mining Co.	British Columbia	Lead, Zinc	Galena, Blende.
St. Joe Lead Co.	Missouri	Lead	Galena.
Timber Butte Milling Co. (Elm Orlu).	Montana	Silver, Zinc, Copper Lead.	Galena, Tetrahedrite, Blende.
Utah Copper Co.	Utah	Copper	Pyrite, Chalcocite.
United Copper Mining Co.	Washington	Copper	Chalcopyrite, Bornite.

In Missouri a number of large installations have been made for treating lead and zinc ores by the agitation air-froth process, but mostly without license from Minerals Separation, Ltd.

In Idaho a number of installations have been made for the treatment of various ores without license from Minerals Separation, Ltd.

In Alaska the Beatson Copper Co. and the Kennecott Mines Co. have installed flotation without license from Minerals Separation, Ltd.

During 1914 the outstanding features of litigation were as follows:

The decision of the Federal District Court in Montana in the case of Minerals Separation, Ltd. *vs.* James M. Hyde, handed down in 1913, was reversed by the Ninth Circuit Court of Appeals at San Francisco in May, 1914. The grounds for the reversal were that the patent sued under was invalid for lack of invention. A rehearing was denied by the same court. Much to the surprise of the mining community generally, the United States Supreme Court decided to review this decision of the Ninth Circuit Court of Appeals on application for a writ of *a certiorari*, and until this decision is handed down, the status of the flotation patents will be indeterminate.

During the year Minerals Separation, Ltd., brought suit against the Miami Copper Co. for an infringement of three of its patents, and the first hearing in this case was held in the District Court of Delaware early in 1915.

The preceding tabulation shows the companies that have installed flotation in North America commercially or for large-scale tests, all of which installations use some modification of the agitation air-froth process.

THE SMOKE PROBLEM IN THE MINERAL INDUSTRIES

By F. G. Cottrell[1]

The problem of maintaining a clear and unpolluted atmosphere is one which grows with our modern civilization and for the most part as a direct result of it.

There are, to be sure, natural phenomena, such as fog and exhalations from decaying vegetation, with which we have to contend in certain instances, but by far the most serious sources of air pollution are man-made.

When coal smoke first came to public notice as the result of the growing use of this fuel, it was looked upon as a distinct and serious menace to the community, and the feeling had grown so strong in England that we find in the time of Queen Elizabeth a law was enacted absolutely prohibiting the burning of coal in London during the sessions of Parliament. Since then the pendulum of public opinion seems, as usual, to have swung to its greatest elongation in the opposite direction, but is now on its return journey, which, let us hope, will be to a position of rational equilibrium where limitation of the smoke evil to the lowest economically practicable point will be rigidly insisted upon without either apathy or hysteria.

The coal-smoke problem has grown to its most aggravated form from the centralizing tendencies of our civilization, *i.e.*, the concentration of life and industry in large cities, and its solution has already begun and must for the most part be worked out through still further developments of this same centralizing tendency by which the direct use of fuels from which it is easily possible to produce smoke will be entirely taken out of the hands of the individual and small operator and centralized in a relatively few large establishments operating economically under rigid smoke control, which in turn will supply the small consumer with heat and motive power in such forms as gas, coke, steam, and electricity. The key to such a solution obviously is well-directed, intelligent coöperation between municipal authority, private capital, and the individual citizen.

This refers only to the smoke due to imperfect combustion of fuel,

[1] Abstracted from "Problems in Smoke, Fume, and Dust Abatement," Smithsonian Report, 1913, pp. 653–685 (Publication, 2307), with the permission of the author.

aside from which are many instances of smoke, fumes, and dust arising from various industrial processes which can not be merely "burnt up" into harmless, invisible gases simply by better combustion.

There are, on the one hand, certain true gases, most of them quite invisible but still harmful to animal and plant life and sometimes even to the very buildings of stone and iron; and, on the other hand, such visible clouds of dust or fumes as can be seen arising from chemical and metallurgical works, cement mills, plaster factories, and the like.

The Sulphur Problem of the Smelters[1]

The treatment and removal of the really gaseous constituents of these trade wastes become such a special problem of chemical engineering in each case that it can hardly be discussed to advantage in the general survey here attempted. There is, however, one case which from its magnitude deserves at least passing comment, viz., the sulphur dioxide gases discharged from smelters operating on the sulphide ores of lead, zinc, and copper, of which the latter, owing to their greater tonnage and higher sulphur content, present the most serious problem. No method has yet been devised which solves this from a practical and economic standpoint for all plants of this character. The most generally applicable method thus far employed has been the manufacture of sulphuric acid. The two chief limits to its commercial applicability in many cases are (1) the lack of a local market for the acid, coupled with the difficulty and expense of its transportation to great distances; (2) the great dilution of the sulphur dioxide with air and other gases in most smelters.

The greatest single use for sulphuric acid to-day is in the manufacture of phosphate fertilizer. The proximity of phosphate rock on the one hand, and of a market for the finished superphosphate fertilizer on the other, are usually determining conditions in this matter. Perhaps the best example of a smelter favorably located in this regard is the Tennessee Copper Co., which has recently installed the largest sulphuric-acid plant in the world. It was driven to this, much against its will, by fume litigation, but is now making more from its acid than from its copper output. As stated, however, its location for such business was ideal, with the phosphate deposits of Tennessee and South Carolina as raw material, and the great southern cotton belt as market for the finished product at its door. It would be difficult to find another plant of this size so favorably located.

When it is considered that there are many smelters in the country,

[1] The following four pages treating of the gaseous constituents are taken, with slight revision, from "Smoke Problems of California," *Trans. Commonwealth Club of California*, 8, 487–492 (1913).

most of them in the West, each of which burns off daily from 250 to 1000 tons of sulphur from its ores into the atmosphere, and that each ton of sulphur will make 3 tons of concentrated sulphuric acid and six of superphosphate fertilizer, the industrial problem of its disposition can be better appreciated.

The cost of smelting in most of the large copper plants of to-day ranges from, say, $1.25 to $2 per ton of ore, depending chiefly on cost of labor, fuel, and power, and as a relatively small per cent. of this often represents the difference between running at a profit or at a loss, it will be readily understood that not many cents per ton of ore smelted can be added for special fume treatment unless the product so recovered can be made to pay part of this cost.

Nor, aside from the cost, would it be easy even to throw away such an amount of acid without doing damage to the surrounding country by its getting into the drainage. The total production of sulphuric acid in the United States at present is about 2,500,000 tons per year, of which probably over half goes into fertilizer manufacture, the most important other consumers being the explosive factories, oil refineries, the steel mills, and miscellaneous heavy chemical factories. Over half of the total amount of acid is manufactured from the sulphur of pyrite imported into this country chiefly from Spain. The low water freight from there to our eastern and southern seaboard, where both the raw phosphate and the fertilizer markets already exist, makes this cheaper than to manufacture the acid from waste gases of our western smelters and then pay freight on the finished product.

The discovery in Idaho and Montana, within the last few years, of what are probably the most extensive phosphate-rock beds yet found the world over,[1] is likely to have a very important bearing on the problem in the future; but even so, the freight rates on the finished fertilizer to the southern and eastern markets are still practically prohibitive, and the demand for fertilizer on our virgin soils of the West is developing very slowly. A few days' output of the sulphur from a single one of our large western smelters would supply sufficient acid for the present yearly fertilizer demands of the whole Pacific coast. However, the consumption of fertilizer in the West has more than tripled in the past 5 years, and eventually this will undoubtedly come to be a factor in the case.

[1] Phosphates: Preliminary Report on the Phosphate Deposits in Southeastern Idaho and Adjacent Parts of Wyoming and Utah, by H. S. Gale and R. W. Richards, *U. S. Geol. Surv. Bull.* 430, pp. 457–535 (1910).

Phosphates in Idaho and Montana, by A. R. Schultz, R. W. Richards, and J. T. Pardee, *U. S. Geol. Surv. Bull.* 530–H (1912).

Fertilizer Resources of the United States, by Frank K. Cameron—Message from the President of the United States transmitting a letter from the Secretary of Agriculture, together with a Preliminary Report by the Bureau of Soils on the Fertilizer Resources of the United States—Senate Document No. 190, 2d sess. 62d Cong.

Besides the manufacture of sulphuric acid there are a few uses for sulphur dioxide itself, the largest consumption being in the wood pulp and paper industry, where it is used as a disintegrating and bleaching agent. It is also used as a disinfectant and preservative, and, to a small extent, in refrigerating machinery, but the tonnage represented by the latter application is comparatively small and does not seem to promise great enlargement; still these uses should not be overlooked as possibilities of disposal of part of the material to be handled. In the case of the wood-pulp industry, we are again met by a new complication. The spent liquors from these mills have proved nearly, if not quite, as hard to get rid of, and as objectionable to the neighbors, as the smelter fumes themselves; and many suits have been brought against the plants for pollution of streams and other nuisances due to these liquors. So, after all, this would simply mean displacing a nuisance from one industry by extending that from another, although in the end it may prove merely a step in the solution of both problems.

As already stated, many proposals have been made to simply dissolve and wash away the gas in solution, but, while in the pure state it is fairly soluble in cold water, its dilution in average smelter gases and the high temperature of the latter make this mode of collection very difficult on a large scale and even if carried out it would leave a veritable ocean of dilute acid liquors which might easily prove more dangerous to the surrounding country and harder to get rid of than the original gases. The neutralization of this liquor with lime has been suggested and, in fact, this procedure actually obtains at the Ashio smelter in Japan,[1] where specially favorable conditions seem to exist, but, as the weight of lime required in some of our smelters would be over half that of the ore, this, too, is only applicable in very special cases.

Another ingenious suggestion has been to moisten the finely ground slag from the smelter itself, and use the metallic bases therein contained as chemical absorbents for the gas, at the same time unlocking and recovering in solution such of the valuable metals as this slag still contains.[2] Up to the present, however, this method has not proved commercially successful, on account of the slowness of the reaction, but its fundamental idea of combining the two great waste products from the smelter for the purpose of further mutual beneficiation of both is certainly an attractive one. Although it does not appear as necessarily hopeless, the difficulties and uncertainties in the way of its practical application are still certainly very great.

[1] The Japan Excursion of the American Institute of Mining Engineers, Jos. W. Richards, *Met. Chem. Eng.* **10**, 20–21 (1912).

[2] The Westby-Sörensen Process, by E. P. Jennings, *Eng. Min. Jour.*, **86**, 418–419 (1908); also U.S. Pat. 875222, Dec. 31, 1907.

Last but not least is the possible alternative of reducing the sulphur dioxide back to solid sulphur, or, better still, so smelting the ore in the first place that as much of the sulphur as possible is given off and collected as such instead of being burnt to its gaseous oxide as at present. Both of these methods for obtaining the sulphur in the free state are now attracting the serious attention of metallurgists.

The earliest experiment, both in the laboratory and on a practical scale, dates back many years,[1] but recently the subject has again come prominently to public attention through experiments on a fairly large scale now being conducted in the western smelters, both on the "Thiogen process,"[2] developed by Prof. S. W. Young, of Stanford University, and the "Hall process,"[3] due to W. A. Hall. The outcome of the practical installations and tests under way are being awaited with much interest.

Even if these methods prove successful at some particular plants, we must not jump at the conclusion that the smelter-fume problem in general is forthwith solved, for except where a ready market can be found for the sulphur produced, the extra cost of the oil or other fuel required would be a serious consideration. By far the greater part of the world's production of sulphur goes at present into sulphuric-acid manufacture, so it is evident this brings us back once more to the question of a market for that substance or the discovery of new uses for sulphur itself. Since sulphur, however, weighs only one-third as much as the sulphuric acid which can be made from it and is an inert solid instead of a corrosive liquid, the conversion of the gas to this form at the smelter may aid in the transportation problem even if it is reburned and manufactured into sulphuric acid at its destination.

There is also the chance of so modifying present smelting practice itself that, with the expenditure of little or no extra fuel, part of the sulphur now being burnt up in the furnaces would be distilled off and collected in the unburnt form. Some of the modern developments in smelting practice during the last few years seem to point strongly in this direction, although here again the possible improvements are probably limited to certain branches or departments only of the work, and part of the sulphur would have still to be taken care of by such other methods as already mentioned.

To sum up: The smelter-fume problem as a whole is really made up

[1] Aeltere und Neuere Verfahren zur Unschädlichmachung des Hüttenrauches durch Abscheidung des Schwefels aus seinen Oxydationsprodukten, by Otto Vogel, *Rauch und Staub*, 3, 68–71 (1912); also Handbook of Metallurgy, by Carl Schnabel, translated by Henry Louis, 2d edition, 1907, vol. **2**, pp. 69–76.

[2] The Thiogen Process for Reduction of SO_2 in Smelter Fume, by S. W. Young, *Min. Sci. Press*, **103**, 386–387 (1911); Thiogen Process Demonstration (illustrated), by L. H. Eddy, *Eng. Min. Jour.*, **93**, 873–874 (1912). See also Vogel, *Rauch und Staub*, **3**, 68–71 (1912).

[3] The Hall Ore Desulphurizing Process, by W. A. Hall, *Eng. Min. Jour.*, **96**, 35–36 (1913). See also Editorial comment and abstracts of patents, *Min. Mag.*, **9**, 92–93 (1913), and **10**, 141–142 (1914); also 1912 British Patents to W. A. Hall, 20757, 20759, 20760 and 26595.

of so many distinct elements, including character and quantity of ore and fuel supply, processes employed, location of works, transportation facilities, available markets for products, etc., that we can not expect to find any one general solution of the difficulty; but it is encouraging to observe from how many different standpoints the question is being seriously attacked by practical men, and from the sum total of the different improvements applied, and diverse outlets for by-products being found, we may with fair confidence look to steady, if not rapid, improvement in the general situation.

The Removal of Incombustible Solids and Liquids

The removal of the suspended particles of solids or liquids which make up the visible clouds of dust and fume may be considered a purely mechanical problem, no matter how fine these particles are, and as such presents interesting general features easily understood without recourse to highly technical considerations.

The chief methods employed for removing such dust and fume from gases may be classed under the heads of washing, filtering, centrifuging, and electrical precipitation.

Washing Methods.—Where washing is employed it is usually accomplished either by a system of fine sprays of water or by bubbling the gases through water or by churning them up with water in various forms of agitators, or by a combination of these. For relatively small volumes of gases having a distinct commercial value—*e.g.*, in the cleaning of fuel gas for domestic use or the scrubbing of iron blast-furnace gas preparatory to use in gas engines—these methods have become well established, but the thoroughness of the scrubbing required, with the consequent amount of power consumed, together with the fact that, where the gases contain acid constituents, very corrosive liquors are generated requiring difficult and expensive acid-proof construction of the apparatus, has thus far set rather sharp limitations to the general extension of this method. A vast number of schemes based on these methods have been proposed and many patents have been taken out, but few who have not actually worked with such methods on a really large scale seem to realize the great difficulty they present from the practical and economic point of view when it comes to dealing with very large gas volumes.

Filtration Methods.—The filtration of gases through fabrics, usually in the form of bags, has found a somewhat wider application to large scale work, notably in the zinc and lead industry. The bag house has the advantage over a washing system in that the material is collected

in a dry state, and for equal volumes of gas treated the expense of installation and maintenance is generally far less than for water scrubbing. The chief limitations of the bag house have arisen from the impracticability up to the present of securing a suitable fabric which would continuously withstand high temperatures, acids, and other corrosive agents in the gases. Cotton bags are very satisfactory for moderately cool gases free from acids, such as met with in zinc-oxide manufacture. Wool bags, though more expensive, will withstand a somewhat higher content of acids and are much used in lead smelting and in some copper smelters, but even their limit is soon reached, and in the majority of copper-smelting plants their use has been considered impractical unless the gases are first neutralized by additions of basic oxides, such as those of calcium or zinc. The resistance to the passage of the gases through the fabric, especially after the solids begin to collect in the pores, is also a serious item in large scale operation, as the fan power required to maintain the draft is often very large.

The use of fine wire screen and of asbestos in place of cotton or woolen fabrics has been repeatedly suggested and extensive experiments have been made with such materials at different plants, but they have not proved generally serviceable, due chiefly to their high cost and the clogging of the pores, rapid corrosion of the wire when fine enough to filter effectively, and the tendency of asbestos to become brittle in highly acid atmospheres.

Besides the bag filters, less use has been made of chambers or towers filled with coke, gravel, sand, sawdust, slag wool, and even asbestos fiber, but for large volumes of gases, especially when they carry a considerable weight of solids, such filter structures if made tight enough to be effective, introduce an enormous resistance and consume a corresponding amount of power, to say nothing of the labor of cleaning, so that their practical use may be considered as confined to rather special cases and relatively small gas volumes.

Settling Chambers and Baffles.—Even the interposition of large flues or chambers in the course of the gases on their way to the stack by temporarily decreasing their velocity greatly aids in settling suspended matter and form a part of almost every metallurgical flue system. If baffles in the form of plates or wires are hung in these chambers, their efficiency as dust settlers is greatly increased, but, of course, at the expense of draft, which must usually be compensated for by additional height of stack or fan power. These chambers are, of course, relatively much more effective as settlers for coarse than for fine particles, and it is impractical by their use alone to effectively eliminate real "fume" or smoke. Probably the largest and best illustration of this system is at

the Anaconda Copper Mining Co.'s smelter at Great Falls, Mont.[1] A few years ago this plant installed in its flue system a chamber 177 ft. wide, 367 ft. long, and 21 ft. deep, with iron wires hung from top to bottom, spaced about 2 in. apart each way throughout the chamber making the aggregate length of wire some 4000 miles, or about equal to the earth's radius. To overcome the resistance to draft occasioned, a new stack was also built 50 ft. in internal diam. and 506 ft. high, the chamber and stack costing over a million dollars, and yet the company considered this a good investment on account of the values recovered from the dust settled by the chamber. Nor is this by any means the largest of the copper-smelting plants in this country. In fact, the same company has another, three times this size, only 175 miles away, at Anaconda. This is mentioned to give some idea of the magnitude of the problems confronting the engineer in smelter-smoke control and the amount of skill and money already expended toward their solution.

Application of Centrifugal Force.—Centrifugal force may be applied to remove suspended particles in one of two main ways. In the first of these the gas is brought tangentially into a stationary container of circular horizontal cross-section and withdrawn vertically upward through the axis of the container, as in the well-known type of cyclone dust catcher, while the dust particles tend to be thrown out to the periphery and finally drop down into a receptacle provided for them beneath. In the second method the gases are passed axially through a rapidly rotating cylindrical shell, preferably provided with some form of baffles. The dust collects on the shell wall and baffles and may be removed from them in various ways.

The first of these methods is in very general use for gases containing fairly coarse dusts, but its efficiency falls off very rapidly, as might be expected, when we come to deal with smaller particles, and on reaching what we usually understand as fume or smoke the depositing action is practically nil.

The revolving shell type is much more efficient in this regard, but the size and high speed necessary in such machinery for treating the large volumes of gases met with in most instances where it would be of interest have made it rather impractical and it has not come into general use.

Electrical Precipitation.—The last method of fume and dust collection to which attention will here be drawn depends upon the use of high potential electrical discharges. This has a somewhat special interest for

[1] "The Great Falls Flue System and Chimney," by C. W. Goodale and J. H. Klepinger, *Bull. Amer. Int. Min. Eng.*, No. 80, pp. 1935–2010 (August, 1913).

the Smithsonian Institution, not merely on account of the interesting scientific problems which surround it, but also because some 3 years ago a group of patents pertaining to the subject were offered to the Institution as the basis for a new and unique form of endowment for scientific research. Out of this has grown the Research Corporation, an organization incorporated to administer the technical and business developments of these and other patents and inventions which may in the future be presented in a similar way to this or other institutions of learning and to return to these institutions for use in scientific research the entire profits arising from such business.

As the methods and aims of this new movement have already been elsewhere fully treated,[1] they may here be passed over, but on account of both the intrinsic scientific interest and the Institution's associations with it, the subject of electrical precipitation of suspended particles will be presented in some detail chiefly by compilation from articles which have appeared in various scientific journals[2] amplified somewhat from unpublished notes on the work, furnished for the purpose by members of the technical staffs, at present busied with these developments.

History of Electrical Precipitation

The removal of suspended particles from gases by the aid of electric discharges is by no means a new idea. As early as 1824 we find it suggested by Hohlfeld[3] as a means of suppressing ordinary smoke, and again a quarter of a century later by Guitard.[4] These suggestions, which do not seem to have stimulated any practical study of the question, were soon entirely forgotten and only brought to light again by Sir Oliver Lodge[5] many years after he himself had independently rediscovered the same phenomena and brought them to public attention in a lecture before the Liverpool Section of the Society of Chemical Industry, November 3, 1886.[6] The first recorded attempt to apply these principles commercially appears to have been made at the Dee Bank Lead Works. The general principle of electrical precipitation

[1] Report of the Secretary of the Smithsonian Institution for the year ending June 30, 1912, pp. 3–5. Also "The Research Corporation, an Experiment in Public Administration of Patent Rights," F. G. Cottrell; *Report of viii Internat. Cong. Appl. Chem.*, **24**, 59–69 (1912). Reprinted in *Jour. Ind. Eng. Chem.*, **4**, 864–867 (1912).

[2] "The Electrical Precipitation of Suspended Particles," by F. G. Cottrell, *Jour. Ind. Eng. Chem.*, **3**, 542–550 (1911). "Electrical Fume Precipitation," by F. G. Cottrell, *Trans. Amer. Inst. Min. Eng.*, **43**, 512–520, 755–762 (1912). "The Control of Dust in Portland Cement Manufacture by the Cottrell Precipitation Processes," by Walter A. Schmidt, VIII, *Internat. Cong. Appl. Chem.*, **5**, 117–124 (1912); reprinted in *Jour. Ind. Eng. Chem.*, **4**, 719–723 (1912). "Electrical Precipitation of Suspended Particles," by Linn Bradley, *Trans. Amer. Electrochem. Soc.*, **22**, 489–497 (1912). "Electrical Precipitation of Cement Dust," Philip S. Taylor, *Jour. Electr. Power and Gas*, Mar. 14, 1914.

[3] "Das Niederschlagen des Rauchs durch Electricität Hohlfeld," *Kastner Archiv. Naturl.*, **2**, 205–206 (1824).

[4] C. F. Guitard, *Mechanics Magazine*, Nov., 1850.

[5] Historical Note on "Dust Electrification and Heat," O. J. Lodge, *Nature*, **71**, 582 (1905).

[6] "The Electrical Disposition of Dust and Smoke with Special Reference to the Collection of Metallic Fumes and to a Possible Purification of the Atmosphere," *Jour. Soc. Chem. Ind.*, **5**, 572–576 (1886), with appended bibliography.

of suspended matter was at this time patented by Alfred O. Walker of the above firm in several countries,[1] but these patents have long since expired. The apparatus was installed in 1885 by the works manager, W. M. Hutchings, with the coöperation of Prof. Lodge, and was briefly described by the former[2] just before its completion as consisting of a system of metallic points situated in the flue from the lead furnaces, and excited from two Wimshurst influence machines with glass plates 5 ft. in diam., each machine being driven by a 1-h.p. steam engine.

The apparatus undoubtedly did not in practice fulfill expectations, as we find nothing further of it in the literature. The most apparent weakness of the project lay, perhaps, in the reliance on the Wimshurst machine, which had then just been brought out and from which a great deal more was anticipated[3] than has been justified by experience, at least as far as commercial applications are concerned. Almost simultaneously with Walker, and apparently without knowledge of his and Lodge's work, Dr. Karl Moeller, of the firm of K. & Th. Moeller, of Brackwede, Germany, secured a patent[4] on electrical precipitation. The patent specification itself appears, however, to be the only published record of this work. The idea was, it is understood, suggested by an article[5] dealing with the disturbing influence on electrometer measurements due to dust in the air.

After this an occasional patent[6] or article[7] served to keep the subject in the public eye, and in 1903 Lodge took out a patent[8] covering the use of the then new mercury arc for rectifying high potential alternating currrents for this purpose, but none of these patents seems to have been carried into successful commercial operation on a large scale in the chemical or metallurgical industries.

Some 8 years ago, while studying various methods for the removal of acid mists in the contact sulphuric-acid process at the University of California, the author had occasion to repeat the early experiments of Lodge and became convinced of the possibility of developing them into commercial realities. The subsequent work may fairly be considered as the reduction to engineering practice as regards equipment and construction of the fundamental processes long since laid open to us by the splendid pioneer work of Lodge, a feat

[1] Great Britian, Patent 11120, Aug. 9, 1884; Belgium, 68927, May 19, 1885; Spain, 7211, July 10, 1885; Germany, 32861, Feb. 27, 1885; Italy, 18007, Mar. 31, 1885; United States, 342548, May 25, 1886.

[2] *Berg.- und Hüttenmänn. Ztg.*, 44, 253-254 (1885).

[3] A. O. Walker, *Engineering* (London), **39**, 627–628 (1885). G. Tissandier, *London Electrician*, **17**, 33 (1886).

[4] Ger. Pat. 31911, Kl. 12, Oct. 2, 1884.

[5] By Robt. Narwald, *Wied. Ann.*, **5**, 460–499 (1878).

[6] Lorrain, British Pats. 6495 and 6567 (1886); Thwait, U. S. Pat., 617618, Jan. 10, 1899; Hardie, U. S. Pat., 768450, Aug. 23, 1904; Blake, U. S. Pat., 913941, Mar. 2, 1909; Dion. 925626, June 22, 1909.

[7] J. Wright, *Elect. Rev.* (London), **47**, 811 (1900); see also *Jour. Roy. Sanitary Inst.*, **27**, 42.

[8] Brit. Pat. 24305 (1903); *U. S. Pat.* 803180, Oct. 31, 1905.

vastly easier to-day than at the time of Lodge and Walker's original attempt.

Theory of Electrical Precipitation

The precipitation of suspended matter, whether in gases or liquids, may be accelerated by electricity in the form of either direct or alternating current, but the mode of action and the type of problem to which each is best applicable differ in certain important respects.

Where an alternating electromotive force is applied to a suspension the action consists for the most part in an agglomeration of the suspended particles into larger aggregates out in the body of the suspending medium and a consequently more rapid settling of these aggregates under the influence of gravity.

Thus, it has been stated that if powerful Hertzian waves are sent out under proper conditions into foggy air the alternating fields set up in space cause an agglomeration of the particles of liquid into larger drops, which then settle much more rapidly. Considerable work aimed at the application of these phenomena to the dispelling of fog on land and sea was said to have been done some years ago in France and England, but very little as to definite results appears to have been published. Another application of alternating current along these lines is found in a process now in use in the California oil fields for separating emulsified water from crude oil.[1]

Alternating current may thus be used to advantage where the masses of fluid to be treated are fairly quiescent, and a simple agglomeration of the suspended particles into larger aggregates is sufficient to effect separation by gravity or otherwise.

In the case of the large volumes of rapidly moving gases in smelter flues the agglomerating and settling process is, however, too slow even when the flues are expanded into as large dust chambers as are commercially feasible. It is in such cases that unidirectional current methods have been particularly important.

If we bring a needle point connected to one side of a high potential direct-current line opposite to a flat plate connected to the other side of the line we find that the air space between becomes highly charged with electricity of the same sign as the needle point, irrespective of whether this is positive or negative, and any insulated body brought into this space instantly receives a charge of the same sign. If this body is free to move, as in the case of a floating particle, it will be attracted to the plate of opposite charge and will move the faster the higher its

[1] See "Dehydration of Crude Petroleum, a New Electrical Process," Arthur T. Beazley, *Oil Age* (Los Angeles), 3, 2–4 (1911).

charge and the greater the potential gradient between the point and the plate.

Even if there are no visible suspended particles the gas molecules themselves undergo this same process, as is evidenced by a strong wind from the point to the plate, even in perfectly transparent gases. The old familiar experiment of blowing out a candle flame by presenting it to such a charged point is simply another illustration of the same phenomena.

As above indicated, the first step toward practicability was of necessity a commercially feasible source of high-tension direct current. The obstacles to building ordinary direct-current generators for high voltages lie chiefly in difficulties of insulation, and if this is avoided as to individual machines by working a large number in series the multiplication of adjustments and moving parts intrudes itself. On the other hand, high potential alternating-current technique has in late years been worked out most thoroughly, and commercial apparatus up to 100,000 volts and over has been available for some years in the market.

The procedure actually used in the installations described below consists in transforming the alternating current from an ordinary lighting or power circuit up to some 20,000 to 75,000 volts through a transformer, and then commutating this high-potential current into an intermittent direct current by means of a special rotating contact maker driven by a synchronous motor. This unidirectional current is applied to a system of electrodes in the flues carrying the gases to be treated. In some cases the wall of the chamber itself acts as one electrode, the other electrode being suspended within it.

The electrodes are of two types corresponding to the plate and point in the experiment cited above. The construction of electrodes corresponding to the plate presents no special problem, as any smooth conducting surface will answer the purpose. With the pointed or discharge electrodes it is quite otherwise, and the working out of practical forms for these proved the key to the first commercially successful installations.

In laboratory experiments when the discharge from a single point or a few such was being studied, fine sewing needles or even wire bristles answered very well, but when it was attempted to greatly multiply such discharge points in order to uniformly treat a large mass of rapidly moving gas at moderate temperatures great difficulty was encountered in obtaining a powerful and, at the same time, effective distribution of current.

It may be of interest to note that the clue to the solution of this difficulty came from an almost accidental observation. Working one evening in the twilight, when the efficiency of the different points could be judged roughly by the pale luminous discharge from them, it was

noticed that under the particular conditions employed at the time this glow became appreciable only when the points had approached the plates almost to within the distance for disruptive discharge, while at the same time a piece of cotton-covered magnet wire, which carried the current from the transformer and commutator to the discharge electrodes, although widely separated from any conductor of opposite polarity, showed a beautiful uniform purple glow along its whole length. The explanation lay in the fact that every loose fiber of the cotton insulation, although a relatively poor conductor compared to a metallic wire, was still sufficiently conductive from its natural hygroscopic moisture to act as a discharge point for this high potential current, and its fineness and sharpness, of course, far exceeded that of the sharpest needle or thinnest metallic wire. Acting on this suggestion, it was found that a piece of this cotton-covered wire when used as a discharge electrode at ordinary temperature proved far more effective in precipitating the sulphuric-acid mist, which was then the object of study, than any system of metallic points which it had been possible to construct. Perhaps the greatest advantage thus gained lay in the less accurate spacing demanded between the electrodes of opposite polarity in order to secure a reasonably uniform discharge. Much of the importance of this discovery at the time lay in the limited potentials of a few thousand volts then available to the experimenters in their laboratory work.

In practice, of course, a more durable material than cotton was demanded for the hot acid gases to be treated, and this was found in asbestos or mica, the fine filaments of the one and the scales of the other supplying the discharge points or edges of the excessive fineness required. These materials were twisted up with wires or otherwise fastened to suitable metallic supports to form the discharge electrodes in such wise that the current had to pass only a short distance by surface leakage over them, the slight deposit of moisture or acid fume naturally settling on them serving to effect the conduction. With the further development of the electrical technique to provide the far higher voltages now being used in commercial operation, the choice and design of electrodes has become much more flexible, including simple metallic wires, sharp metallic strips, and the like. In fact, the very phenomena of so-called corona loss or direct leakage from the wire into the air on high-tension transmission lines, which are to-day the chief stumbling block of the power companies in going very far above 100,000 volts on these lines, become exactly what is desired in the processes of precipitation, and with the voltage now used a bare metal wire of moderate size or the relatively thin edge of a metallic sheet may be made to furnish an excellent discharge.

The construction and arrangement of the electrodes, as also of the chamber containing them, naturally varies very widely with the conditions to be fulfilled under the varied applications to which the process may be put. Some of the more general features of this work are described in patents[1] already issued in this and foreign countries, while further details and modifications are covered in other patents not yet issued from the various patent offices.

Laboratory Experiments

For the original laboratory experiments in the spring of 1906, sulphuric-acid mist was generated by bubbling SO_3 gas through water in a U tube beneath an inverted glass bell jar whose inner walls were quickly wetted sufficiently with acid to act as the collecting electrode, a wire inserted alongside of the stopper through which the U tube connected with the bell jar serving to connect the jar walls to an induction coil, the latter acting as a step-up transformer. This coil received alternating current at 110 volts from the lighting circuit and gave about 3700 volts at its secondary. The other high potential terminal of the induction coil was connected to the discharge electrode within the bell jar through a make-and-break, operated by the synchronous motor. This latter was improvised by substituting a plain iron cross for the squirrel-cage armature in an ordinary fan motor operated from the same 110-volt line as the induction coil and brought into step by the induction motor on the right. A momentary contact with the discharge electrode was thus established once each complete cycle at the peak of the voltage wave and served to charge this electrode to the maximum voltage of the line, always with the same polarity. As stated above, electrical precipitation takes place no matter whether the discharge electrode is made the positive or negative, and the direction of the discharge and deposit is independent of the polarity and determined only by the size, shape, and surface of the opposing electrodes; but it is found in practice that the negative discharge is much the more stable and can be run at higher current without danger of disruptive discharge, so that it has now become standard practice to make the discharge electrodes the negative and the grounded collection electrodes the positive.[2] In order to help maintain the charge on the electrode in the interval between these contacts, a Leyden jar was connected in parallel with the electrodes. The wire leading to the jar walls or collecting electrode was usually grounded for

[1] U. S. Pats. 866843, 895729, 945917, 1016476, 1035422, and 1067974. The second of these also practically reprinted by *Eng. Min. Jour.*, 86, 375–277 (1908), Ger. Pats. 258435, 265964, and 270757 and corresponding patents in various other countries. See also in this connection Ger. Pats. 205740, 230,570, and 238958.

[2] The Positive and Negative Corona and Electrical Precipitation, W. W. Strong. *Trans. Amer. Inst. Elec. Eng.*, 32, 1305–1314 (1913). Also U. S. Pat. 1067974, Cottrell, July 22, 1913.

convenience and safety, as, in fact, has been done throughout all the practical installations. This leaves but one high-potential conductor to deal with in each precipitation chamber and greatly increases the safety of operation.

The next undertaking was to duplicate these experiments on a scale some two hundred-fold larger. This was carried out during the same summer at the Hercules works of the E. I. du Pont de Nemours Powder Co. at Pinole, on San Francisco Bay, where the contact gases from one of their Mannheim contact sulphuric acid units were employed. The apparatus was the same in general principle as the small laboratory unit described above. The precipitated acid drained off from this precipitation chamber into a carboy. Current was supplied from three 1-kw. 110-volt to 2200-volt transformers connected in series on their 2200-volt side to give 6600 volts. In this apparatus the power consumption was about one-fifth of a kilowatt, and between 100 and 200 cu. ft. of gas per min. could readily be treated.

First Commercial Installations

These experiments at Pinole attracted the attention of the Selby Smelting & Lead Co., whose smelter, located at Vallejo Junction, a few miles farther up the bay, was at that time the object of injunction proceedings brought by the farmers of the surrounding country. At the time the suits originated three separate stacks at the smelter contributed to the alleged nuisance. The first, and admittedly the most serious offender, handled the gases from the lead blast furnaces and discharged several tons of lead fume daily into the air. Shortly before the commencement of electrical precipitation work at the plant this had been obviated by the installation of a bag house.[1] After correcting this evil there still remained, however, a stack discharging the gases from the roasters, which, besides the invisible sulphur dioxide, furnished dense white clouds, consisting chiefly of sulphuric acid, arsenic, and lead salts, and to which the bag-house was inapplicable on account of the corrosive action of these gases upon the bags. Lastly there was the stack of the refinery carrying the mists escaping from the pots of boiling sulphuric acid used to dissolve the silver out of the gold and silver alloy coming from the cupels.

The blast furnace and the roaster stacks each carried something over 50,000 cu. ft. of gas per min. while the refinery stack represented scarcely a tenth of this volume. As a first step operations were accordingly commenced on this latter, and after several months' experi-

[1] For detailed description see *Eng. Min. Jour.* **86**, 451–457 (1908).

menting as to the best form of construction a system of vertical lead plates 4 in. wide by 4 ft. in length and spaced about 4 in. apart was adopted. Several rows of such plates were assembled in a 4 by 4-ft. lead flue. Between each pair of plates hung a lead-covered iron rod carrying the asbestos or mica discharge material, the latter finally proving the more serviceable in this highly acid atmosphere. These rods or discharge electrodes were supported on a gridwork of buss bars extending over the heads of the plates and through apertures in the sides of the flue to insulators on the outside. Dilute sulphuric acid (about 40° B.) runs out from the flue as precipitated. When the acid kettles are at a full boil it often amounts to over 2 gal. a min.

The electric current is taken from the power circuit of the plant at 460 volts, 60 cycles, and transformed up to 17,000 volts, thence through the synchronous contact maker or rectifier to the electrode system. At first a glass-plate condenser was connected across the high potential line in parallel with the electrode system in order to assist in maintaining the potential of the electrodes between the intervals of contact, but was found troublesome and unnecessary in practice and in this and other installations is now omitted.

The power consumption for this installation is about 2 kw., including the driving current for the synchronous motor, and the whole apparatus requires no more attention than a feed pump or a blower. This appears to have been the first commercially successful installation of electrical precipitation ever made, and has now been in regular daily operation for over 7 years at a cost for labor attendance and repairs of less than $20 a month. In fact, while the plant was making enough bluestone to utilize all the weak acid recovered, the saving on purchase of the latter paid for the entire cost of operating five times over.

In the 7 years which have elapsed since this installation was made the processes have undergone steady development, and incidentally have passed through the many vicissitudes common to innovations in the industrial world. One of the first extensions of the work was naturally a series of experimental precipitation chambers in the main roaster flue of the same works. One form was of lead construction similar to that of the first installation but of some ten-fold larger capacity, and another was of brick and iron construction and intended for the collection of drier and less highly acid-bearing material. Later, fundamental changes in the furnace equipment and metallurgical practice at this plant obviated the need for electrical precipitation and the permanent installation originally contemplated for these particular flues has never been carried out.

Operations in Shasta County

The installation next in order of size to be undertaken was at the Balaklala Smelter at Coram, Shasta County, Cal., 273 miles north of San Francisco on the main line of the Southern Pacific Railroad to Portland and Seattle. The vast body of low-grade copper ore reaching for many miles across this county and commonly known as the Copper Crescent, has been described in detail by L. C. Grafton[1] and characterized as the second largest copper deposit which can be considered as a single geological unit in the United States. From the viewpoint of smelter smoke litigation this region has a particularly interesting history.

The first commercially successful smelter in this region was erected at Keswick in 1896 by the Mountain Copper Co. (Ltd.), under the management of Louis T. Wright, and was of especial interest as one of the pioneers in pyritic smelting. Extensive heap roasting was also carried on at this plant with the result of widespread deforestation of the surrounding country and the final closing down of the plant in 1905 through injunction proceedings instituted by the United States Forestry Service. The company has since built a small smelter and acid phosphate works at Martinez, on San Francisco Bay, and now ships its ore to this point, nearly 250 miles distant, for treatment, but even this latter plant has at various times come in for its share of fume litigation.

In 1901 the Bully Hill Smelter, at Delamar or Winthrop, with a capacity of 250 tons a day, was started. This was later purchased and is now owned by the General Electric Co., but since July, 1910, it has been closed as a result of complaints by the United States Forestry Service, who insisted at that time that the plant either close or at least commence efforts on a practical scale looking toward controlling its fumes.

In 1905 the Mammoth Copper Mining Co., a subsidiary of the United States Smelting, Refining & Mining Co., blew in its present smelter at Kennett. This plant when running full has a capacity of some 1200 tons of ore per day.

The Balaklala, or First National Copper Co., was the most recent of the Shasta County smelters, having blown in its first furnace in 1908.

These smelters are all situated in the narrow precipitous canyon of the upper Sacramento River and its tributary, the Pitt. The region itself is too steep and rocky for agriculture, but was once heavily wooded, although now swept bare of vegetation for miles. As far as the canyon itself is concerned, probably all the damage possible has already been

[1] *U. S. Geol. Surv. Bull.*, 430b.

done unless reforestation were undertaken. This latter even would probably be slow and difficult work, as since the loss of vegetation the steep hillsides have been washed bare of soil for miles around. At Redding, however, some 13 miles below Coram and 17 miles below Kennett, the canyon widens out into the fertile Sacramento Valley and from this point southward for some 12 miles farther lies the region from which came increasingly insistent complaints against the smelters. These culminated in the spring of 1910 in agreements between the farmers and the smelters under which friendly suits were brought in the Federal courts and injunctions issued by stipulation requiring the smelters to remove the suspended matter from their exit gases and dilute the latter to such an extent that their sulphur dioxide content should not exceed seventy-five hundredths of 1 per cent. by volume as discharged from the stacks, with the further general and sweeping provision that they should do no damage.

To accomplish this the Mammoth Smelter installed a bag house, which has been in very successful operation since July, 1910. The gases discharged from five stacks (each 21 ft. square) are to all intents and purposes free from suspended matter and consequently invisible. This represents a notable achievement, being the first time that the bag house, so efficient in lead smelters, has been successfully applied to copper blast furnace gases on a large scale.

It is made possible in this instance through neutralization of the sulphuric acid in the gases by the zinc oxide carried over in the fume from the very heavy zinc content of the ore smelted. The company is also the owner of patents[1] on the introduction of finely divided metallic oxides into the gases for this purpose. In addition, it was necessary to provide an extensive system of cooling pipes. There are 40 of these pipes, each 4 ft. in diam. and averaging about 200 ft. in length. They represent a very large part of the cost of the installation. It was expected that they would be sufficient to cool the entire gases of the plant to a safe temperature to protect the $30,000 worth of woolen bags with which the house is filled, but upon starting up with the gases passing through all the pipes in parallel it was found that only a little over half the full capacity of the plant could thus be treated with safety and operations were accordingly restricted to this. In the cold weather of winter a considerably larger tonnage can be handled with safety than during the hot summer. Subsequently by rearranging the pipe connections so as to have eight groups in parallel, each consisting of five pipes in series, the company succeeded in greatly increasing their efficiency as coolers,

[1] Clarence B. Sprague, *U. S. Pats.* 931515, Aug. 17, 1909, and 984498, Feb. 14, 1911. See also W. C. Ebaugh, *Jour. Ind. Eng. Chem.*, 1, 686–689 (1909) and 2, 372–373 (1910). Also "Notes on Bag-Filtration Plants," by A. Eilers, *Trans. Amer. Inst. Min. Eng.*, 44, 708–735 (1912).

and thus materially increased the plant capacity over that first obtained. Provision was also made to supplement the pipe cooling by the blowing in of outdoor air when necessary. The fan power necessary to move all this vast weight of air and furnace gases through the bags and pipe system is of course considerable, reaching at times well up toward the 1000-h.p. mark. Notwithstanding this, however, the bag-house is to be considered a decided success, at least for the particular conditions met with at this plant, and the management deserves great credit for the courage and skill with which it has carried through this new and after all largely experimental undertaking, representing as it does the expenditure of over a quarter of a million dollars.

In the case of the Balaklala Smelter, the use of a bag-house was also considered, and in fact a small experimental unit containing a few bags was run for some months in comparison with tests both by the electrical process here described and also a centrifugal apparatus in which the gases passed through a rapidly rotating cylindrical shell equipped with radial baffles to insure the gas being raised to full velocity. As a result of these tests the electrical process was adopted for the full-sized installation.

The smelter was treating from 700 to 1000 tons of 2½ to 3 per cent. ore carrying over 30 per cent. of sulphur with considerable but varying amounts of zinc, the greater proportion of this being handled in blast furnaces, but the fines including everything under an inch and amounting to less than 10 per cent. of the whole going through McDougall roasters and an oil-fired reverberatory. The plant has also two converter stands. The gases from all these departments passed into a common flue 18 by 20 ft., in cross-section. The volume of gases passing through this flue varied with operating conditions from a quarter to half a million cubic feet a minute, which means, in round numbers, a mean linear velocity in the flue of 10 to 20 ft. per sec.

Before attempting to design the full-sized equipment for treating these gases a small precipitation chamber capable of treating about 1 per cent. of the total gases was erected and an extended set of experiments made with it.

With this miniature unit as a guide, the equipment of the whole plant with similar apparatus was undertaken in March, 1910. This was completed and first put into operation the end of the following September and, with the exception of a couple of weeks in December, remained in continuous operation until July 24, 1911, when the whole plant shut down until such time as a practical method could be found for removing from the gases not only the suspended solids, but the sulphur dioxide gas as well. Experiments to this end with the Hall process

already referred to, upon at least a semi-commercial scale, have since been pursued by the Balaklala Co. at the smelter; but no decision seems yet to have been reached regarding their commercial practicability on the full-sized operating scale of the smelter. These experiments on sulphur dioxide have, however, nothing fundamentally to do with the electrical precipitation, and returning to this it may be said that the 9 months' operation of the plant amply demonstrated the entire practicability of extension of the process to operation of this and even larger scale.

As was naturally to be expected many difficulties were encountered, some of which were quickly overcome, while others gave way more gradually before the systematic study of operating conditions.

At the rectifier building the current was received from the company's three-phase power circuit at 2300 volts, 60 cycles, and after being transformed up to from 25,000 to 30,000 volts under the control of the operator through variable resistance and induction regulators was rectified into an intermittent direct current, as already explained, and distributed to the individual precipitating units.

The collecting or grounded electrodes, each 6 in. wide by 10 ft. high, are made of No. 10 sheet iron. The discharge electrodes consist of two iron-wire strands between which was twisted the discharge material, for which both asbestos and mica preparations were at various times used in this plant. Each unit contained 24 rows of 24 electrodes of each type. The collecting electrodes were carried by bars connected directly to the frame of the chambers themselves, while the discharge electrodes were spanned by springs between a system of buss bars carried on externally placed insulators. To the auxiliary chambers surrounding these insulators a small regulated amount of air was admitted to prevent conductive dust or fume from working back and settling on the insulators.

The cam and shaker rod extending across the middle of the unit was originally designed for the purpose of vigorously shaking the electrodes, as it was greatly feared that the removal of precipitate from the electrodes in units of this size might be one of the most serious problems. In actual operation it was found, however, that the electrodes could easily be shaken by hand from the top entirely free from dust, the whole operation including cutting the unit in and out of the system and the removal and replacement of its covers, requiring only about 10 min., this having to be repeated every 6 or 8 hr., depending on the dust content of the gases. The precipitated dust and fume as it fell from the electrodes was carried by the conveyor in each unit

to a common longitudinal conveyor, which in turn discharged into cars carrying it away for treatment and recovery of its values.

Filtration tests upon the gases before and after the electrical treatment throughout the 9 months of operation showed that this plant under favorable working conditions precipitated between 80 and 90 per cent. of the suspended matter in the gas, the average over the whole period of operation being somewhat less, while after introducing improvements in detail of construction on one of the units shortly before the final shutdown of the plant the efficiency of this unit was carried well up into the nineties. Under average operating conditions at the smelter some 6 to 8 tons of precipitate were collected per 24 hr.

The gas-treating plant as a whole, including flues, fans, motors, and electrical apparatus, cost, up to the time it was first put in operation, a little less than $110,000. Although many minor changes were later made, none of the larger or more expensive elements of construction was greatly altered.

The total average power consumption for the precipitation plant was in the neighborhood of 120 kw. One man could readily control the whole operation in the rectifier house, although as a matter of precaution for a new plant under the high tension here used, two were usually on duty. Two laborers and a foreman were employed on the precipitating units and dust-handling system, although this could have been reduced somewhat by automatic shaking devices, as in the Riverside Plant described below.

The volume of gases treated varied considerably with the conditions at the furnaces, but may fairly be taken as averaging between 200,000 and 300,000 cu. ft. per min., and entering the units at from 100 to 150° C.

Work at Other Western Smelters

This plant, while not able to save the Balaklala smelter from an eventual shutdown, formed a very important link in the development of the processes to their present status. The interest of the smelter companies up to this point depended almost entirely on the hope of eliminating smoke as a nuisance and its attendant litigation with their neighbors; and had it not been for the life or death struggle that this meant to them, it is probable that the success of the electrical processes might have been delayed many years longer. Once brought, however, under this powerful stimulus to the state of development above described, the importance of these processes for the saving of values lost through waste gases began to claim general interest, and at present a large number of precipitating plants are under construction and several are

already operating in copper, lead, and iron smelters, metal refineries, cement mills, and a varied set of chemical industries.

It is unnecessary here to describe any of these plants in great detail as they represent essentially the same principles as those already discussed, but the accompanying illustrations may serve to give an idea of the present trend of the subject. An experimental unit was erected about the end of 1911 at the Garfield copper smelter in Utah to treat the gases from basic lined converters handling a copper matte carrying a small percentage of lead. In this case 5-in. steel pipes carrying the gases acted also as grounded or collecting electrodes, the discharge electrodes being wires stretched axially within them. The deposited material was shaken down from time to time by striking the pipes with a system of hammers attached to the rocking shafts passing behind the front row of pipes. This deposit consists chiefly of basic lead sulphate, carrying gold, silver, and other values. This unit consisted of 24 pipes and was followed by another one of 600 pipes, which was successfully operated for about a month on steady tests taking the whole of the gas from one large basic converter and some of the time a part of that from another one as well. A part of this equipment was then moved to a point where gases from the other departments—that is, blast furnaces, reverberatories, and roasters—could also be secured, and experiments continued on each of these and on mixture of them. They were all found to be easily handled, the others in fact even more easily than the converter gases, but these latter contained the highest values. Having determined to build a new flue system and dust chamber for the blast furnace and converter gases at Garfield, it was decided to incorporate an electrical precipitation plant for the treatment of all the converter fumes. This entire project is now under construction, and in the planning of this flue system provision has also been made for the installation of an electrical precipitation plant for the treatment of blast furnace gases, should it later be decided to do so. The precipitation plant for the converter gases is expected to be in operation by fall of this year.[1]

Another installation to treat about 100,000 cu. ft. of gas per min. and consisting of 384 pipes, each 13 in. in diam., is also under construction at the lead smelter of the Consolidated Mining & Smelting Co. at Trail, British Columbia.

Another unit of tubular type with pipes of lead, 12 in. in diam. and 12 ft. long, was constructed at Anaconda to collect the copper and acids volatilized from an 80-ton experimental MacDougall furnace, roasting low-grade sulphide tailings with salt preparatory to leaching.[2]

[1] "Electrical Fume Precipitation at Garfield," by W. H. Howard, *Bull. Amer. Inst. Min. Eng.*, No. 92, pp. 2029–2046, August, 1914.

[2] "Roasting and Leaching Tailings at Anaconda, Mont.," by Frederick Laist, *Bull. Amer. Inst. Min. Eng.*, No. 79, pp. 1147–1162, July, 1913.

Where the material collected is largely liquid or saturated with acid, as in this case, both wood stave and vitrified terra-cotta pipes up to 2 ft. in diam. have also been used with success, and with dry material iron-pipe construction has been successfully employed up to 36 in. diam. and 20 ft. in length. In these larger pipes several discharge electrodes are sometimes employed, carried on a central support.

This type of construction, when applicable, has done much to simplify and reduce cost of installation.

Problems of the Portland Cement Industry

The Portland cement industry is another direction in which the precipitation process has proved of very practical importance. The first installation of this kind was made under the direction of Mr. Walter A. Schmidt at the mill of the Riverside Portland Cement Co. near Riverside, Cal. Threatened litigation with the owners of surrounding orange groves on account of nuisance and damage to fruit and trees from the dust clouds of lime and clay escaping from the cement kilns was the incentive for the cement company undertaking the work. The company had already spent upward of a million dollars in purchases of surrounding land and other expenses connected with the nuisance and damage question, but without securing permanent relief. Experimental work on electrical precipitation was commenced there in the summer of 1911; and as this was almost the first practical extension of the processes to temperatures of 400° to 500° C., many new engineering features had to be worked out. The details of the final plant were worked up through a series of preliminary experimental units of progressively increasing size. Had there been sufficient ground space available near the base of the kiln stacks the precipitating units might have been placed there and a more compact and far less expensive installation secured; but as it was, the only available space seemed that above the roof at the top of the old stacks. Furthermore, the cement company preferred to incur this additional expense rather than suffer any delay or interruptions of its regular operations while changes were being made in the flues or stacks themselves.

Consequently a reinforced concrete platform 90 by 190 ft. was built 80 ft. above the ground, strong enough to support the entire electrical equipment, upward of 1200 tons of steel going into the installation as a whole. The present plant consists of 10 rotary kilns, each 8 ft. in diam. by 100 ft. in length, fired with crude petroleum and furnishing a total volume of nearly a million cubic feet of gas per min. to be treated. Out of this the electrical equipment now collects nearly a hundred tons of dust per day.

The treaters are of somewhat the same general type as those used at the Selby and Balaklala smelters, but larger, with wider electrode spacing and many improvements over these in details and general design. There are 20 of them in all, two to each kiln stack, connected to it on opposite sides through louvre dampers. The grounded electrodes are plates of heavy wire screen reinforced by angle iron ribs, and the discharge electrodes are light iron wires.

The operating gallery, running the whole length of the row of treaters, contains the motor-generator sets, rectifiers, and transformers, together with their control switchboards, as well as the compressed-air valves governing the operating machinery of the damper and the shaking devices for dislodging the dust from the electrodes. This dust falls into hoppers, from whence it passes by a system of screw conveyors and automatic scales to the storage and car-loading bins. The whole installation requires but one operator, and the electrical-power consumption, including motor-generator and transformer losses, is about 35 kw. The cost of the installation was somewhat less than $200,000. As stated, it was installed purely to overcome the dust nuisance, and was not expected to return any significant values, as the dust is not finished cement, but chiefly raw mix carried out by the gases before it has reached the clinkering zone. The raw mix used contains, however, a small percentage of potash (usually not exceeding 1 per cent. K_2O), which largely volatilizes and most of which is condensed and caught in soluble form in the dust, making the latter, even in its crude form, as collected, a fertilizing agent which finds a ready market at nearly as good a price as the finished cement, or by using it over again in the raw mix of a separate kiln a second and higher concentration of the potash may be effected in the dust caught from this.

We thus have another example of a plant, put in at a supposed loss purely to avoid trouble with the neighbors, proving not only to cover its own operating expenses, but actually to pay a rather handsome return on the very considerable investment involved. The plant has been in uninterrupted operation on this basis since January 8, 1913. As this article goes to press the first unit of similar character east of the Mississippi is about to go into service, and in Europe another is under construction.

Further Development in Progress

A number of other installations, each with its features of special interest, might also be referred to, but sufficient has been said to indicate at least in outline the field developing before these processes.

As early as 1907 Mr. Erwin Möller, son of Dr. Karl Möller, already

mentioned as one of the pioneers of electrical precipitation, had independently taken up this work in Europe and is now coöperating with the American investigators whose work is described above in the further development of the subject, having also joined with them in the assignment of patent rights to the Research Corporation for the benefit of the Smithsonian Institution.

Sir Oliver Lodge and his sons are also once more active in this field and are likewise joining very cordially in the general spirit of coöperation. Their recent technical contributions to the subject[1] have been chiefly in the lines of rectification and insulation, the most novel and essential element of which is a special form of vacuum tube which permits the current to flow through it in one direction only. This may be used either by itself or preferably in conjunction with a mechanical rectifier such as those already described. It appears to have been first devised and used for experiments on the stimulation of growing crops by high potential unidirectional discharges,[2] but its applicability and importance in precipitation work is now being thoroughly investigated, and positive data on this from large-scale tests should soon be available. It is only within the last year that a really active commercial development of the electric precipitation processes has been undertaken in Europe, but at the present time several installations are under construction in various countries, and it is hoped that later a detailed report of this work may also be possible.

More Recent Reoults[3]

By Linn Bradley

In the installation at the Raritan Copper Works, Perth Amboy, N. J., after they had passed through a water scrubber which was supposed to recover practically all of the values very corrosive gases were encountered. Many materials of construction were experimented with—even ductile tungsten, which, at that time (1912), was not readily obtainable. The construction problem finally was solved by the use of heavy cast iron in parts and a lead-antimony alloy for other parts. Insulation and natural draft troubles also were encountered but finally they were overcome with the result that the installation has already saved several thousand dollars' worth of valuable fume. The power consumption is about 2.5 to 3 kw. and the voltage averages about 35,000. Recently we have installed some 12-in. and some 24-in. diam. lead pipes for additional treaters which are of very simple construction. These operate very successfully and mark a distinct advance over the old type treater in several respects. Lately there has been installed at this plant a 10-kv-a., 25-

[1] Brit. Pats. 25047 and 25047a (1905), also 29268 and 29269 (1912).
[2] John Ernest Newman and Lionel Lodge, Brit. Pat. 17046 (1907).
[3] Abstracted from a paper before the American Institute of Electrical Engineers, February, 1915, by permission of the author.

cycle single-phase 100,000-volt transformer, a 500-rev. per min. motor-generator set, and a large rectifier. With this equipment greater spacing between electrodes is possible and the operation is generally improved. Occasionally some of the deposited fume, which is a good conductor of electricity, drops between electrodes and draws a heavy arc. This used to cause the automatic circuit breaker to open and an auxiliary circuit to ring a bell and notify the attendant. An automatically operated mechanism was developed and installed, thus overcoming this trouble and increasing the values recovered.

A small treater was installed for the Vulcan Detinning Company for removing hydrated tin chloride from the exit gases from a chlorine detinning plant. The hydrochloric acid, free chlorine and tin chloride together constituted one of the worst fumes for human beings that we have yet encountered. The tin chloride and a portion of the acid and the chlorine were recovered but the final installation never was completed because the plant manager feared that water vapor might be drawn back through the treater and into the anhydrous gas lines, thus closing them and stopping operations due to a solid compound resulting from the reaction between the water and the anhydrous tin chloride. The original treater insulation was not fully satisfactory, although it permitted most successful operation if it was occasionally cleaned. A modified treater of simple construction was suggested whereby all the remaining difficulties could have been overcome, but it was not installed. The electrical equipment easily and completely precipitated the tin compounds for which it was installed, but for various commercial reasons the use of the processes was discontinued. With the present knowledge and the experience gained since then, the problem could be easily and cheaply solved even with the original electrical equipment. The problem of insulation at the point where the high-tension current entered the treater was really the most difficult to solve because of such fumes; the later designs overcame this.

A treater was operated by the Balbach Smelting & Refining Company on the gases from cupelling furnaces but the value of the material recovered did not warrant its continuous operation. It was believed that the losses were considerably greater than the actual collections indicated, so the treater was shut down and experiments thereafter were conducted upon a small scale, because of the greater ease of changing conditions with a small apparatus than with the large treater. One purpose was to obtain a close estimate of the total fume values being lost from the furnaces, as this would decide whether work would be continued. Results of operations to date are highly encouraging and

success upon the final scale is assured. The volume of gas is about 10,000 cu. ft. per min.

Tests at the plant of the Orford Copper Company, on a semi-commercial scale were successful. Various kinds of gases were treated and a large amount of data obtained which would be useful when the full scale apparatus was installed. The various flues, stacks, etc., were studied, and plans and specifications for equipment to handle all the gases were prepared and submitted with our report. The values recoverable from the gases apparently would not be sufficient to warrant the heavy installation expense; therefore, before deciding to incur the financial risks incident to such a large installation, especially when only an alleged nuisance was involved, it was decided to await further developments. It is quite likely that the large installation eventually will be made at this plant.

At the plant of the Hooker Electrochemical Company, a large volume of air, containing a small percentage of chlorine gas, is treated for the removal of the latter. Hydrated lime dust is used to assist in the removal, and a few tons per day of weak bleaching powder are collected. The volume of gas is about 30,000 cu. ft. per min., with a power consumption of from 3 to 5 kw. Weak bleaching powder, chlorine gas and hydrochloric acid are not conducive to a simple insulation problem, as can be readily imagined; nevertheless it was successfully handled, even for 50,000 volts. In this case our most difficult problems have not been concerned with the electrical processes, but, on the contrary, have been to obtain a steady introduction of hydrated lime into the gas and at a given rate.

Gases from sintering machines and roasters at Salida, Colorado were to be treated, but the tests made in the latter part of 1912 did not indicate that the values in the gases at the time were sufficient to warrant the expense of installation. The plant management had been endeavoring to reduce their lead losses to a minimum by close chemical control of the material fed to the furnaces. It is possible, however, that this plant may find that it is more desirable to use the electrical processes than to exercise such careful control over the charge. Recent developments have so reduced installation costs that the problem may be reconsidered, especially since the processes are now in successful use on similar gases at another lead smelter.

Tests were conducted on a semi-commercial scale at the Kings County Foundry with results showing that complete recovery of the fume was feasible. The gases come from cupola furnaces in which old tin cans and other metal scrap are reduced to a poor grade of iron which is made into sash weights. The fumes consist mostly of tin, lead and

zinc oxides and the quantity per day is considerable. The cost of separating and refining the metals, when they are in the proportion as shown by analyses of the collected material, is such that the expense of the installation has not yet been incurred by the company which proposed to operate it, and therefore the scheme has remained dormant since the completion of our tests and submission of our report. When a process has been perfected for treating these fumes economically so that the tin, lead and zinc can bring something close to their market value, the field is a good one in which to build up another by-product industry. As these sash weight foundries are operated at present it would be necessary to install a fairly extensive system for cooling the gases down to a reasonable working temperature. Of course, such apparatus increases the cost and helps to make difficult the profitable collection of these fumes at the present time.

Elaborate tests upon gas volumes, composition, temperature, fume content, etc., were conducted for the Chase Rolling Mill Company in order to secure reliable data upon which to base designs for full scale commercial installations. The fume is mostly zinc oxide originating at the crucibles in which zinc and copper alloys are produced. Many tests were conducted with the electrical processes while the gas conditions were varied as to velocity, temperature, etc. The results were very gratifying, showing that the financial returns would pay well. Plans have been prepared for large commercial installations at the various locations and a contract for a portion of the installation has been awarded. Some very valuable data and information were obtained in the investigations at this plant and these will be useful in many other installations also. Early in the testing work at this plant such discouraging results were obtained that some of our own technical men considered it to be a hopeless task, and it was with great difficulty that they were induced to renew the work and carry it to so favorable a stage as it is now. The management of the plant kept its faith throughout the trying periods when tangible results seemed to be the exception, and its course is to be commended.

An installation at Omaha, Nebraska, for collecting sulphuric acid mist arising from so-called "parting kettles" in a silver refinery, practically identical with the Selby, California, installation was also very successful.

The semi-commercial treater used early in the testing work at Garfield was subsequently shipped to Murray, Utah, and tests were conducted at the lead smelter with excellent results. The smelter already was equipped with a large and expensive bag house, and for this reason it was not necessary to immediately install the electrical processes. The

analytical results showed nearly 100 per cent. of the suspended particles of fume and acid removed in the electrical tests, thus proving the effectiveness of the processes.

Small scale tests were conducted on gases from sintering machines at Tooele, Utah, carrying large amounts of lead, elementary sulphur, etc., and upon gases from roasters, converters and blast furnaces. In all cases the results were satisfactory. Two large units are now in successful commercial operation on the sintering machine gases and it is planned to install several others on these gases as soon as possible, and later to install treaters on other flues at this plant as well. Each of the two units contains 48 pipes 12 in. in diam. by 15 ft. long, placed vertically. The electrode spacing is 6 in., the volume of gas treated is approximately 20,000 cu. ft. per min., the power consumption measured at the transformer at present is less than 5 kw., the recovery of fume, when the treaters are not overloaded by forcing the blowers at the sintering machines, is practically complete. The fume contains a fair percentage of elementary sulphur, which formerly wrought havoc with bag-house installations, especially when it exploded. The potential on the treater as indicated by transformer ratio and primary voltage, is around 70,000 volts. At this plant also some changes in the metallurgical operations have resulted in a considerable reduction of the values lost in the fumes, hence the electric processes are not called upon to recover as much as was being lost a year or so ago.

Without having conducted any preliminary tests, a full scale treater was designed, erected and placed in operation for the Goldschmidt Detinning Company. The necessary alterations were very few and unimportant before a complete recovery of the tin compounds was being effected. The temperature of the gases sometimes reaches 800° F. in the treater itself. Occasionally the white fumes and black coal smoke alternate. One can then observe the successive layers of white and black fume precipitated upon the electrodes and by this aid can determine if the gas speed in all compartments of the treater is practically equal. There are nine 12-in. iron pipes, the voltage may range from 60,000 to 80,000, the power consumption from 600 to 1500 watts.

In response to a telegraphic request apparatus was shipped to the Washoe Smelter, Anaconda, Montana, to be used for removing valuable metals and acids from gases arising from a modified MacDougal roaster, in which the Anaconda tailings were being subjected to an oxychloridizing roast. The gases at that time were being passed through a scrubbing tower without obtaining a complete recovery of the values. The electric apparatus and treater were quickly erected and tried out but at first with what appeared to be unsatisfactory results. As similar

phenomena had been encountered elsewhere it was possible to soon show that the cloud emerging from the treater was due to moisture being condensed from the gaseous to the liquid condition upon the gases mixing with cold air, resulting in a condition of supersaturation for the temperature existing after admixture of the gases. It was also noted that if the furnace fires were poked so as to produce black smoke, no black could be discerned in the cloud above the treater when the electric field was on, but this was plainly visible when the current was turned off; —the difference between the white cloud (current on) and the dark gray cloud (current off) being very pronounced. This was a good indication that all solids were being collected and that by a study of certain meteorological tables the proper explanation might be had. The temperature of the gases going to the treater was then so reduced that no cloud would result after the gases had passed through the treater. The results then showed a complete clean-up when the current was on and a dense white cloud above the treater when it was off. Some photographs were taken to show the remarkable effect and also the suddenness with which the electricity produced it. Some very good moving pictures of these fogs or clouds and their elimination were made at the time. Twelve-in. diam. lead pipes, 20-in. diam. wood stave pipe, and 24-in. diam. stoneware pipes were tested and all proved successful. It was interesting to view the tops of the pipes while in operation. One could see an absolutely clean gas over the cross-section, except at a short distance from the pipe on which the cold liquid was deposited. One readily could observe how the fog was produced in a manner similar to a cloud formation when exhaust steam leaves a locomotive stack on a cold and humid day. The name "tea-kettle effect" has been suggested for lack of a more appropriate and shorter term.

The processes were for some time thereafter used in the tests at Anaconda to check up the furnace losses, as they could be depended on to collect nearly everything that escaped from it, and plans were being prepared for a large installation at the proposed leaching plant, but the later improvements in roasting and leaching made it unnecessary to add salt to the roaster and this in turn reduced the losses to such an extent that it was considered unnecessary to recover the values.

An installation of the process was made at the Arsenic Plant where flue dust is roasted to remove the arsenic from the metal values, and then the concentrated arsenic is recovered and refined. The plan was to separate the mechanically carried impurities from the gases at a high temperature, next cool the gases so as to condense the pure arsenic, and then recover it directly, thus saving a second refining. The first test gave a precipitate in the second treater carrying 99.4 per cent. arsenic

trioxide. A portion of the impurity was due to volatile compounds from the wood used for fuel. Coke fuel in place of wood gave arsenic of a higher purity, sometimes reaching 99.9 As_2O_3.

This was the first really serious effort made to use electrical precipitation as an adjunct in fractionating components of fume, although some previous attempts had been made at Perth Amboy, N. J., in our work there on the silver refinery fumes. The results at the Arsenic Plant showed conclusively that it was a feasible method and, after sufficient data had been obtained, a commercial installation was designed and started, but construction work was suspended on account of the situation resulting from the European war and this installation has therefore not yet been completed; although reports state that it is now going forward. Tests have also been made on a semi-commercial scale on the gases from the blast furnaces, converters and roasters, with satisfactory results. They have even exceeded in size the 3-ft. pipe originally installed at the Arsenic Plant, by using an iron pipe 4 ft. in diam. as the collecting electrode, and a 250,000-volt transformer and mechanical rectifier to correspond. This latter is quite inexpensive although it is subjected to such enormous electric stress.

Treating the enormous volume of gases in the main flue at Anaconda presents several problems. In addition to magnitude there are the numerous problems connected with the handling of the fumes and dust and of their metallurgical treatment, so that it will be some months at least before any very definite progress can be reported. However, the results thus far obtained were so encouraging that the smelting company purchased a license for the use of the processes throughout their plants at Tooele, Great Falls and Anaconda, paid a large cash sum, and now they are in position to make rapid progress with their installations. The Research Corporation still has a financial interest in certain elements of the fume which are to be collected when the processes have been installed.

At Catasauqua, Pa., is an installation for collecting potash salts volatilized from feldspar. This is operating successfully although the volume of gas being treated is greater than was specified by the owner's engineers. This undoubtedly is the first commercial installation in the United States built primarily for the production of potash salts, the residue being the by-product. At present the scheme as a whole is still in the experimental stage, but the collection of the salts by the electrical processes is proved. The treater was designed for 12,000 cu. ft. per min., but it handles as high as 18,000 cu. ft. per min. at times. There are 40 pipes 14 in. in diam. by 12 ft. long, the electrode spacing being 7 in. The temperature of the gases ranges from 500 to 1000° F. A potential of

about 70,000 volts (calculated as mentioned above) is maintained on the treater, low tension alternating voltage about 190, and 20 to 25 amp. The power factor varies between 70 and 80 per cent. when operating on the hot gases and fume. This same treater has been tested with only ordinary air in it, and at that time it was easy to furnish even more than 50 amp. to the transformer without any arcing in the treater. This is a good example of a difference in electrical conditions due to a change in the gas characteristics.

Other problems upon which tests have been made with the processes are mentioned below. The most recent final installation was made in Worcester, Mass., at the North Works of the American Steel & Wire Company for collecting volatilized hydrochloric acid, thus mitigating or eliminating a nuisance and preventing further damage to surrounding vegetation. The wire company's own tests were so successful that it waived all requirements and asked that an invoice be rendered at once so it could make prompt payment and close up the account. No experimenting was required on this installation, thus testifying to the thoroughness with which the preliminary survey was made before designing the apparatus. The exit gases are so free from acid that it is almost impossible to detect a trace of it even by delicate chemical methods.

In Cleveland, Ohio, at a sulphuric acid plant, the gases come from an M. & H. kiln in which very finely divided zinc sulphides are roasted. The sulphurous gases are to be freed from the suspended particles and then delivered to a Glover tower of a lead-chamber sulphuric acid plant. The gases are to be treated at a temperature of about 800 to 1000° F. The gases contain some free sulphuric acid which tends to complicate the insulation problem. However, our semi-commercial tests at this plant showed that the problems could be solved, and pointed the way. Designs of several types of treaters were prepared and at a recent conference one design of a horizontal treater was decided upon and it is to be installed at once. There are to be three sections, any two of which will clean the gases. Thus one section may be repaired when necessary. In this problem it is necessary to conserve the sensible heat of the gases and to avoid their dilution with air as this would materially affect the subsequent chemical operations.

An installation for collecting sulphuric acid mist coming from a roasting furnace is under construction for the Standard Essence Company, and since it is so similar to other sulphuric acid mist problems, no difficult features are anticipated.

The problem has been surveyed for the Duquesne Reduction Company; gas data as to volumes, temperatures, draft power, etc. were

obtained; the volume of gas to be treated is about 11,000 cu. ft. per min. at a temperature of 600° F. Tests with electrical equipment showed the probable amount of dust obtainable and indicated how a large treater would operate. Contracts have been let for the full scale installation and work is being pushed as rapidly as possible. The dust and fume contain tin, lead and zinc oxides, from waste metals. The probable values are so large that an excellent profit is expected. The first treater contains 48 pipes 12 in. in diam., and actual operation shows a much greater recovery than was anticipated.

Similar data to that mentioned above has been obtained at a waste-metals plant of the National Lead Company. The probable recovery of values strongly warrants the immediate installation of the processes and advices to that effect have recently been received. The electrical process tests were highly satisfactory, and enabled one to obtain a dependable opinion as to the values now being lost, practically all of which can be collected readily. The outcome of the investigations and tests is very gratifying, especially when it is known that some of their employees declared that their losses were only nominal.

Owing to various reasons beyond our control, tests of the electrical processes for the cleaning of iron blast furnace gases at the Bethlehem Steel Company were delayed. Arrangements now are being pushed so as to commence tests on a fairly large scale at the earliest possible date. It should be feasible to employ the processes either for cleaning these gases for stoves and boilers, conserving the sensible heat contained in the gases when they come from the furnace top, or for gas engine purposes, having cooled the gases previously. Perhaps both schemes will be tested at Bethlehem's plant, although the dry and hot gases will be handled first. The results are expectedto have a very important influence in this field.

Arrangements have been made and a license sold to the Baltimore Copper Smelting & Rolling Company for installations of the processes to collect sulphuric acid mist, under conditions similar to those at the Selby and Omaha plants, and for collection of valuable fumes from the silver refinery, similar to that of the Raritan Copper Works. Such excellent results had previously been had with these two types of problems and success was so apparent that the company purchased a license for a cash sum, in lieu of royalties.

In addition to collection of materials, because of nuisance or of value of the suspended matter, it is worth noting that the processes are useful as adjuncts to other manufacturing processes or methods, either for improving operations or reducing expense. Both the lead-chamber process and the contact processes of producing sulphuric acid have several places in which the electrical processes should be valuable.

REFRACTORY MATERIALS

By Kenneth Seaver

During the year 1914 the general depression of business throughout the country naturally had a very material effect in decreasing the production of refractory materials. In some cases, such as that of magnesia brick, although the demand was considerable, the production was necessarily curtailed, due to the inability to secure the Austrian magnesite from which practically the entire output of magnesia brick in this country has been manufactured. This supply of magnesite from Austria-Hungary was ultimately entirely cut off, and despite quiet business conditions, the rate of consumption of basic refractory materials was sufficient to totally deplete stocks of magnesite carried.

Of the three general classes of refractories, comparative quantities of each, manufactured in the United States in 1914, may be roughly divided as follows:

	Per cent.
Silica brick	18
Fire clay brick, including bauxite brick	80
Magnesite and chrome brick	2

While in recent years the progress in the development of refractory materials and knowledge concerning them has been noteworthy, the advances in their intelligent application in the various industries have been even more marked. During the past few years many ultimate economies to the consumer have resulted from the introduction of certain classes of refractories for uses to which they were previously considered entirely unadapted.

While the chemical composition and theoretical physical properties of certain refractories may make them apparently suitable for certain particular uses only, a careful study of temperature conditions as affecting reactions, coupled with the courage to undertake actual practical tests, has often greatly widened the scope of their availability.

Other changes in the applications of refractories have been brought about by material improvements in industrial processes.

Silica Brick

Of the silica brick produced in the United States, approximately 75 per cent. is manufactured in Pennsylvania. In the vicinity of Mount

Union and Hollidaysburg, Pennsylvania, the ganister or quartz rock from which silica brick is made occurs on the mountain slopes in floes varying in depth from a few feet to as much as 20 ft. In these localities ganister or quartzite occurs in the Medina and Oneida sandstone formation. The extensive measures here carry good rock in limited, but well-defined, areas. The Pennsylvania rock, like that found in Alabama, is gray in color, while the Wisconsin ganister has, as a whole, a darker and more reddish appearance. The Wisconsin ganister used in the manufacture of silica brick in the Chicago district occurs also in comparatively restricted areas. The Alabama quartzite has not yet been distinctly located geographically, but occurs in more widely scattered and somewhat smaller deposits. Analyses of the various rocks are closely similar.

The general procedure in the manufacture of silica brick, like many commercial processes formerly considered vital industrial secrets, is now very general knowledge. Good silica brick are manufactured from selected rock of high silica content, usually over 97 per cent., and often higher. This rock is crushed and then ground to the proper size in a wet pan, to which is then added, during the grinding 2 per cent. of lime in the form of milk of lime. After thorough and uniform mixing in the wet pan, the mass is moulded by hand in steel moulds. The brick are then transferred to the dryer, where they are subjected to a temperature of about 300° F. (150° C.). Burning is accomplished at about 2900° F. (1595° C.), usually in a down-draft kiln. At this temperature a portion of the quartzite is changed to cristobalite, which inversion accounts for the expansion always accompanying the burning of silica brick. The lime, which serves to give a good set to the brick on drying, is converted to the silicate, thus forming the bond. An average analysis of the burned silica brick is as follows:

	Per cent.
Silica	96.10
Alumina	0.90
Ferric Oxide	0.70
Lime	1.80
Magnesia	0.14
Alkalies	0.39
	100.03

Due to the improved methods of annealing silica brick in the burning process, they have become tougher and considerably more resistant to abrasion. As a result of increasing experience this material is continually finding a wider scope of application, and it would be a rash guess to estimate the limit of its future possibilities.

The rather high coefficient of expansion of silica brick causes spawling when subjected to rapid changes in temperature within certain limits. The greatest expansion of silica brick, which is about 0.18 in. per ft.,

occurs at temperatures below about 1200° F. (650° C.). For this reason greater precaution must be taken at the lower temperatures. Above that 1200° F. (650° C.) the expansion is negligible, and it is unnecessary to provide for a fine control of the temperature as far as its effect on the brick is concerned.

This tendency of silica refractories to spawl upon sudden temperature changes below a definite point, in some cases renders it unsuited for certain purposes, while its other properties may be ideal. By proper design to suit such conditions, in many instances it has been made possible to use silica brick to great advantage. In other words, the operating conditions sometimes may be adapted to the refractory in preference to applying an inferior refractory to the practice under the existing conditions.

A notable illustration of this is in the use of silica brick in lime kilns. In the past few years silica brick have taken the place of first quality fire clay brick in an appreciable measure. They are supplanting the clay bricks in the hot zone and even in the fire-boxes and arches in lime and dolomite kilns, sometimes increasing the service from 200 to 300 per cent. It must, however, be properly handled.

Silica brick are used in rotary dolomite and lime kilns, and when properly installed and used are giving wonderfully increased service. Here, as in the shaft kiln for calcining limestone and dolomite, a strongly basic material comes into intimate contact with the acid lining, but inasmuch as the temperature employed is not sufficiently high to cause chemical reactions, the silica material does not flux nor deteriorate, as might at first be supposed. Neither does the lime or dolomite become contaminated with the silica refractory.

The large application of silica brick in the construction of by-product coke ovens is of almost wholly American adaptation, although now becoming better recognized abroad. In view of the large amount of new construction of this nature now under way, it is an important field.

In recent years silica brick have completely supplanted clay and quartzite brick above the floor line, and to some extent in other portions.

Silica brick is a better thermal conductor by from 20 to 25 per cent. than fire clay and quartzite brick. Several years ago 24-hr. coke was normal, but in the past few years the use of silica brick with high thermal conductivity and high refractoriness has made greatly lessened coking-time possible. Among the advantages of silica over clay and quartzite brick in by-product coke practice are its high refractoriness (having a fusion point of at least 3100° F.) and its capacity to sustain heavy loads at higher temperatures.

Silica brick deteriorate little under the action of the volatile constitu-

ents present in normal coals, and do not shrink, but expand, on heating. This expansion is absolutely definite and may be nicely controlled by suitable allowance for expansion joints.

Another development worthy of note in the application of silica brick is its more extensive use in enameling furnaces. The ware to be enameled is heated in a chamber, entirely by conduction and radiation. In this process it is essential that the combustion gases do not come in contact with the ware to be burned, and due to the expansion of silica, making possible very tight joints, it is admirably suited for the construction of such furnaces.

Other experiments on a rather large scale now under way, such, for instance, as those to determine the possibility of its application in the combustion chambers of hot blast stoves for blast furnaces, indicate a greatly increased use of silica material in the future.

In this particular practice it will probably prove successful in connection with washed gas, but will flux when the furnace may be operated on fine ores and the gas is unwashed. The consequent deposit of flue dirt at the temperatures involved would be active in destroying the brick.

Under suitable conditions silica brick have been successfully used in boiler arches. Generally speaking, however, the temperature variation in boiler construction is too great to warrant any general recommendation of its use.

The mention of these several experiments with silica refractories only suggests some of the possible uses to which this material may sometimes be applied.

Fire-clay Refractories

Kaolin, or the purest form of fire clay, is a hydrous silicate of alumina, having the formula $Al_2O_3 \cdot 2SiO_2 \cdot 2H_2O$, corresponding to the following percentage composition: silica, 46.3, alumina 39.8, water 13.9 per cent., or dehydrated, silica 53.8 and alumina 46.2 per cent. The fusing point of pure clay is about the same as that of platinum, or about 3200° F. (1760° C.). Fire clays are of approximately the same composition as the theoretically pure clay, with the exception that they contain varying percentages of impurities such as lime, oxides of iron, magnesia, and alkalies, and vary more or less in their proportions of silica and alumina content. Like the kaolins, they have been derived from feldspathic deposits. The purer or flint clays are lacking in plasticity, while the soft clays, which contain more impurities and are consequently less refractory, possess plasticity to a greater degree.

The simplest case of the manufacture of fire-brick is that in which the highly refractory flint clay is incorporated with a highly refractory

plastic clay in proper proportions to mould it into the desired shapes. In the manufacture of high-grade fire-brick the clays are mined, carefully selected, and if desirable, weathered. The flint and plastic clays, after being broken into small lumps, are mixed in the proper proportion and ground in the wet pan to a suitable consistency and degree of fineness. The mix is then moulded into shape, tempered on the hot floor, and re-pressed. It is then thoroughly dried and burned at a temperature of about 2700° F. (1480° C.). By this hand-made process, the brick are more porous and better able to withstand sudden changes of temperature.

A departure from this well-established process has been taking place in the noticeable development of the machine-made product in the manufacture of first-quality blast-furnace brick. The machine-made brick are more uniform with respect to the grind, due to the method of manufacture. The clay is mixed and ground in a dry pan and automatically screened, the material of proper size going to the pug mill, while the tailings are returned to the pan and re-ground. After pugging, the mass is tempered in the wet pan, then pressed on a steam or other powerful press. Re-tempering follows, after which the brick are re-pressed. A brick made by this process is considerably denser than the hand-made brick.

The machine-made brick have increased in demand until to-day the calls for hand- and machine-brick for the blast furnace are about equal.

With the introduction of the thin-lined water-cooled blast furnace, which necessitates the use of the highest grade of refractories, much improvement in the development of a brick of uniform dimensions and of greater density was accomplished by using a mixture of clays, giving a minimum shrinkage and maximum bond without a sacrifice of the refractoriness. Such brick have proved to resist abrasion to a surprising degree, they do not spall, and are practically impermeable to gases.

In hot blast stoves the recent tendency has been to use brick of higher refractoriness and greater density.

In boiler settings the application of fire-brick has been greatly improved upon by correcting defective design and altering the construction. Here again a remarkable development has been taking place in the substituting of first-quality fire-brick for second- and third-grade material previously so generally used for this purpose.

This general tendency to substitute first-quality fire-brick for inferior grades has been exceptionally noticeable in the past few years.

The neutral refractory materials of commonest use are bauxite and chrome iron ore, and carbon or graphite. Of these the bauxite is most widely employed in the industries, while chrome is without question the next most commonly used.

Bauxite Brick

A high grade of bauxite ore is essential for the manufacture of good bauxite brick. Bauxite is a hydrous oxide of aluminium, and the ore used in the manufacture of refractories is of the following approximate analysis.

	Per Cent.
Silica, SiO_2	4 to 7
Ferric oxide, Fe_2O_3	3 to 5
Alumina, Al_2O_3	60
Water, H_2O	30

On account of the excessive shrinkage of bauxite, it is necessary to calcine it at very high temperatures to entirely eliminate this shrinkage. The calcined blocks, or dobies, are ground, mixed with a suitable bond, and carefully burned at an extremely high temperature by a slow burning process.

Aside from the high fusing point of the bauxite brick, which is about 3400° to 3600° F. (1870–1980° C.), it is highly resistant to basic slags and coal clinker. Somewhat like silica, bauxite brick have a tendency to spall with rapid temperature changes, but not to nearly so great a degree as silica brick. Unlike silica, however, bauxite brick shrink, rather than expand, at high temperatures.

The great density of bauxite brick, which accounts for the spalling property, makes this material the more resistant to fluxes. As a result of this same property, coal ash of low point of fusion will not readily adhere to the dense resistant bauxite brick. Clinker which adheres to the highest grades of fire-brick, when broken away, takes with it big pieces of the brick; so firmly does it adhere that it will not separate from the brick. It is pleasing to note the economies resulting from the use of bauxite in place of fire clay brick in fire-boxes in boiler settings. Bauxite built in the fire chamber for six or eight courses around the clinker line offers an excellent means of overcoming the difficulty mentioned above. Clinker of the most fusible type does not readily adhere to bauxite brick, but comes away from it freely, leaving the brick in a good clean condition.

In a great number of cases in which first quality fire clay brick had been used in the boiler fire-boxes, dependent upon the conditions, from 4 weeks to 6 months was the maximum life of the refractory, while with bauxite along the clinker line, from four to six times the service is readily obtained.

Bauxite has been gradually, but quite rapidly in the past few years, finding successful application as linings in rotary kilns used for calcining dolomite, lime and magnesite. By means of it the life of the lining has been materially increased. In the cement practice bauxite is also being used to advantage in increasing quantities for lining rotary cement kilns.

Several steel concerns are experimenting with bauxite on a rather extensive scale, endeavoring to substitute it for magnesite in parts of the open-hearth furnace.

DATA OF THE WORLD'S PRINCIPAL MINES

By S. F. Shaw

Compiled from Annual Reports of the Respective Companies

Name of Mine.	Location.	Year.	Tonnage Produced.	Profits.	Dividends.	Ore Reserves, Tons.	Cost per Ton
Abosso Gold	W. Af.	'12–'13	104,400	.....	.....	266,401	.....
Ahmeek	U. S.	1913	283,749	176,919	1,100,000	.....	.....
Alloues	U. S.	1913	263,663	155,728	.....	.....	$2.09
Amalgamated Zinc	Aus.	½–1914	247,386	290,000	.....	.....	.....
Anaconda	U. S.	1913	4,651,445	11,323,498	12,997,500	.....	7.10
Anchor Tin	Tas.	'12–'13	86,240	£56	.....	.....	0.99
Arizona Copper	U. S.	'13–'14	1,079,950	£288,255	£157,521	.....	3.56
Ashanti Goldfields	W. Af.	'13–'14	97,293	£145,731	£147,327	432,500	14.78
Assoc. Gold Mining	Aus.	'13–'14	127,856	£11,467	£12,384	33,306	5.35
Assoc. Northern Blocks	Aus.	'12–'13	97,639	£38,452	£35,000	.....	.....
Balaghat Gold	India.	1913	42,700	£2,348	.....	21,886	.....
Baltic	U. S.	1913	333,289	230,211	200,000	.....	2.76
Blackwater	N. Z.	1913	45,052	£20,631	£12,499	104,727	6.67
British Broken Hill	Aus.	½–1913	95,662	£50,968	£52,909	.....	.....
British Columbia Copper	B. C.	1913	353,422	58,325	88,756	.....	.....
Broken Hill North	Aus.	½–1914	156,020	£157,658	£150,000	.....	4.33
Broken Hill Block 10	Aus.	1914	37,853	– £4,691	£12,500	.....	.....
Broken Hill Block 14	Aus.	½–1914	23,810	£4,245	£10,000	.....	7.64
		½–1914	19,821	– £608	£10,000	.....	9.25
Broken Hill Proprietary	Aus.	½–1914	139,991	£150,714	£107,050	.....	.....
Broken Hill South	Aus.	½–1914	172,178	£141,100	£140,000	.....	5.86
Buffalo	Ont.	'13–'14	77,616	388,187	660,000	54,116	.....
Bunker Hill & Sullivan	U. S.	1913	436,663	1,119,961	817,500	3,842,010	2.73
Butte & Superior	U. S.	1913	296,940	937,794	.....	.....	8.71
Calumet & Arizona	U. S.	1914	64,702	.....	.....	.....	.....
Camp Bird	U. S.	'13–'14	30,595	£70,292	£45,500	25,709	.....
Cape Copper	Cape Col.	'12–'13	72,756	£83,500	£69,000	161,970	.....
Carn Brea & Tincroft	Eng.	½–1914	29,795	– £3,681	.....	.....	5.60
		½–1914	29,373	– £283	.....	.....	5.17
Centennial	U. S.	1913	85,443	31,549	.....	.....	2.52
Champion	U. S.	1913	421,849	504,767	900,000	.....	3.06
Champion Reef	India.	'13–'14	216,934	.....	£138,667	477,384	.....
Chino Copper	U. S.	1913	1,942,700	3,021,887	1,919,070	90,000,000	2.46
Coniagas	Ont.	'13–'14	54,522	989,618	.....	260,086	.....
Con. Goldfields of N. Z.	N. Z.	1913	23,661	£6,292	.....	.....	.....
Con. Main Reef	Tran.	'13–'14	241,257	£116,609	.....	693,460	5.30
Con. Mining & Smelting	B. C.	1914	374,771	474,012	464,376	.....	.....
Copper Queen	U. S.	1914	732,829	.....	.....	.....	.....
Creston	Mex.	1913	130,654	.....	.....	306,300	.....
Crown Mines	Tran.	1913	2,483,622	£1,442,473	£1,034,116	10,449,000	3.94
Crown Reserve	Ont.	1914	31,635	239,447	424,515	.....	15.90
Daly-Judge	U. S.	1913	48,943	.....	180,000	.....	.....
Detroit Copper	U. S.	1914	477,582	.....	.....	.....	.....
Dolcoath	Eng.	½–1914	57,254	£510	.....	.....	5.73
		½–1914	48,058	£898	.....	.....	5.93
Dolores	Mex.	1913	41,952	.....	None.	100,932	.....
Dome	Ont.	'13–'14	145,305	.....	.....	.....	.....
East Butte	U. S.	1913	186,815	.....	None.	.....	10.07
El Dorado Banket	Rhod.	'12–'13	87,176	£101,414	£90,000	74,826	6.89
El Oro Mg. & Ry.	Mex.	'12–'13	253,434 tailing.				
			180,274 ore.	.....	57,375	448,053	.....
El Rayo	Mex.	1913	.....	.....	None.	54,800	.....
Esperanza	Mex.	1913	207,443 tailing.	.....	.....	.....	.....
			85,843 ore.	491,232	247,500	113,500	.....
Ferreira Deep	Tran.	'12–'13	647,550	£631,432	£490,000	1,974,400	4.88
Franklin	U. S.	1913	123,179	.....	None.	160,162	.....
Franklin Furnace	U. S.	1913	490,434	.....	.....	.....	.....
Frontino & Bolivia	Bol.	'12–'13	32,888	£13,443	.....	15,900	11.29
Gaika Gold	Rhod.	'13–'14	36,927	£29,126	£27,349	100,770	6.30
Giant	Rhod.	'12–'13	131,887	£75,645	£77,125	.....	3.84
Globe & Phoenix	Rhod.	½–1914	37,517	.....	£120,000	188,000	9.72
Glynn's Lydenberg	Tran.	'12–'13	40,642	£38,216	£3,400	.....	7.07
Golden Horseshoe	Aus.	1913	280,512	£42,698	£60,000	715,496	5.40
Goldfield Con.	U. S.	1913	349,465	2,731,945	2,491,404	136,000	6.38
Great Boulder Perseverance.	Aus.	1913	244,841	£6,897	.....	516,978	4.21
Great Boulder Proprietary	Aus.	1913	189,469	£301,657	£262,500	614,114	5.86
Great Cobar	N. S. W.	'12–'13	288,172	£81,925	.....	2,390,280	.....

Name of Mine.	Location.	Year.	Tonnage Produced.	Profits.	Dividends.	Ore Reserves, Tons.	Cost per Ton.
Great Fingall	Aus.	1913	64,255	− £12,550	.....	.....	.....
Great Fitzroy	Aus.	'12–'13	107,098	£549	.....	.....	9.09
Greene-Cananea	Mex.	1913	673,034	.....	1,093,143	.....	.....
Grenville	Eng.	½–1914	21,483	£1,869	.....	.....	6.50
		½–1914	24,515	.....	.....	.....	.....
Hecla	U. S.	1913	141 930	292,696	320,000	.....	.....
Hedley Gold	B. C.	1913	70 796	405,255	360,000	.....	5.61
Hollinger	Ont.	1914	208,936	1,786,679	1,170,000	.....	4.50
Homestake	U. S.	1914	1,587,774	.....	2,210,208	.....	.....
Hutti Gold Mines	India.	1913	27,733	.....	.....	30,000	.....
Independence	U. S.	'13–'14	.....	72,000	29,800	.....	.....
Inspiration	U. S.	1913	.....	.....	None.	89,643,000	.....
Iron Blossom	U. S.	1914	40,480	306,150	400,000	.....	14.67
Iron Silver	U. S.	1913	49,668	.....	.....	.....	.....
Isle Royale	U. S.	1913	313,679	232,302	150,000	.....	2.45
Ivanhoe	Aus.	1913	239,314	.....	.....	991,417	.....
Jumbo Gold	Rhod.	'12–'13	37,180	− £17,350	.....	.....	.....
Kalgurli	Aus.	'13–'14	127,820	£101,330	£96,000	200,000	4.69
Kerr Lake	Ont.	'13–'14	33,955	620,785	615,000	.....	.....
Knights Deep	Tran.	'13–'14	1,112,800	£135,865	£74,352	2,480,000	2.94*
Kyshtim Corp	Sib.	1913	351,043	£311,578	£314,058	356,000	.....
Lake Copper	U. S.	'12–'13	83,109	− 52,441	None.	.....	3.27
LeRoi No. 2	B. C.	'12–'13	35,555	.....	43,740	.....	7.12
Lena Goldfields	Sib.	'13–'14	.....	£50,658	£57,914	.....	7.41
Lucky Tiger	Mex.	1913	.....	.....	450,662	.....	4.38
Main Reef West	Tran.	'13–'14	212,852	£56,640	.....	526,640	5.63
McKinley-Darragh-Savage.	Ont.	1913	.....	771,487	1,023,937	.....	.....
Mexican	U. S.	1913	15,973	.....	.....	.....	10.40
Mexico Mines of El Oro	Mex.	'12–'13	.....	£191,886	£162,000	.....	.....
Miami	U. S.	1913	1,058,754	1,534,685	1,491,979	20,300,000	3.39
Minerals Separation	Aus.	1913	.....	£5,090	.....	.....	.....
Moctezuma	Mex.	1913	603,654	2,402,447	1,950,000	.....	.....
Mohawk	U. S.	1913	366,458	.....	500,000	.....	.....
Montana-Tonopah	U. S.	'12–'13	52,402	.....	100,000	32,000	.....
Mt. Bischoff	Tas.	½–1913	116,063	163,000	173,000	.....	1.18
Mt. Elliott	Aus.	'13–'14	37,875	259,000	178,000	533,750	.....
Mt. Lyell	Tas.	½–1914	163,596	£61,954	£80,424	3,122,723	7.00
Mt. Morgan	Aus.	'13–'14	303,428	£199,054	£200,000	3,125,000	11.94
Mysore	India.	1913	302,662	2,352,000	1,824,000	1,377,102	.....
Nevada Con	U. S.	1913	3,169,108	2,345,564	3,998,914	39,108,590	2.95
Nevada Hills	U. S.	1913	41,919	176,966	None.	.....	7.95
Nevada Wonder	U. S.	'13–'14	48,578	247,743	281,636	.....	4.65
New Idria	U. S.	1914	62,578	− 45,010	10,000	.....	5.44
New York & Honduras Rosario.	Hond.	1913	91,606	575,343	220,000	355,396	9.81
New Modderfontein	Tran.	'12–'13	565,400	£483,926	£420,000	4,547,000	5.46
New Reitfontein	Tran.	1913	185,830	£14,225	£15,252	57,737	4.84
Nipissing	Ont.	1913	77,240	1,824,365	1,800,000	216,644	14.81
North Butte	U. S.	1913	462,799	.....	820,000	.....	.....
North Star	U. S.	1913	106,090	.....	300,051	.....	.....
Nourse	Tran.	'13–'14	539,800	£160,879	£155,216	2,443,700	5.42
Nundydroog	India.	1913	90,650	.....	475,200	.....	7.28
Old Dominion	U. S.	1913	169,961	481,445	690,000	.....	.....
Ooregum	India.	1913	153,536	£174,832	£129,251	189,947	5.44
Oriental Con	Chosen.	'13–'14	301,162	622,780	644,780	822,500	3.57
Oroya-Black Range	Aus.	'12–'13	59,680	.....	.....	.....	6.46*
Oroya Links	Aus.	1913	139,130	£15,899	.....	146,775	3.86*
Osceola	U. S.	1914	1,108,447	353,677	289,541	.....	1.45
Otavi	W. A.	'13–'14	50,070	.....	.....	.....	.....
Ouro Preto	Brazil.	1913	66,139	− £3,503	.....	114,528	6.59
Pahang Con	Malay.	'12–'13	127,543	£49,796	£36,874	.....	5.55
Portland	U. S.	1914	273,129	590,595	360,000	.....	4.80
Prestea Block A	W. A.	1913	229,990	£38,340	.....	691,670	7.37
Princess Estate	Tran.	1913	257,476	£4,505	.....	614,000	6.05
Progress	N. Z.	1913	34,996	− £2,431	.....	.....	7.74
Ray Con	U. S.	1913	2,366,007	2,398,466	1,631,504	78,380,966	2.38
Rio Tinto	Spain.	1913	1,859,571	£1,673,372	£1,487,500	.....	.....
Robinson	Tran.	1913	668,900	3,500,000	2,010,000	10,073,000	3.83*
Robinson Deep	Tran.	'13–'14	619,140	£324,532	£275,000	1,533,000	4.13*
Rooiberg Minerals	Tran.	'13–'14	11,422 tailing.				
			29,181	£51,131	£31,500	20,097	12.02
Round Mountain	U. S.	'12–'13	57,360	29,150	.....	155,500	4.55
Santa Gertrudis	Mex.	'13–'14	393,836	£126,627	.....	967,000	.....
San Toy	Mex.	1913	7,056	.....	115,000	.....	.....

Name of Mine.	Location.	Year.	Tonnage Produced.	Profits.	Dividends.	Ore Reserves, Tons.	Cost per Ton.
Selukwe-Columbia	Rhod.	'12–'13	37,263	£14,662			
Seoul Mining	Chosen.	1913	71,535		500,000	592,418	4.13*
Shannon Copper	U. S.	1913	264,584	476,440	150,000		
Sheba Gold	Tran.	'12–'13	68,920	£42,281	£47,304	110,000	8.31
Silver King Coalition	U. S.	'12–'13	100,225		500,000		10.50
Simmer & Jack Prop.	Tran.	'12–'14	769,900	£322,678	£337,500	2,320,000	3.00
Snowstorm	U. S.	1913	105,674	137,455	112,463		
Sons of Gwalia	Aus.	1913	162,101	£66,277	£66,300	625,000	
South Crofty	Eng.	1914	69,342	£2,653	£4,375		5.00
South Kalgurli	Aus.	'12–'14	124,670	£6,572	£6,250		4.96
Spasaky Copper	Sib.	1913	33,663	£226,318	£152,850	342,883	
Stewart	U. S.	1913	174,126		561,434		
St. John de Rev	Brasil.	'12–'14	175,823	£128,676	£10,000	887,400	8.41
Sudan Goldfields	S. A.	1913	17,049	29,000		42,862	
Sulphide Corporation	Aus.	'12–'14	209,074	£165,227	£200,000		
Superior & Pittsburgh	U. S.	1914	485,796				
Talisman Con	N. Z.	'12–'14	41,680		£120,750	37,515	13.78
Tamarack	U. S.	1913	227,563	−49,923	None.		
Taqua Mining & Exp.	W. A.	'12–'13	61,607	£39,696		196,502	
Tasmania Gold	Tas.	'12–'13	52,812	−£3,028			8.38
Tennessee Copper	U. S.	1913	470,135		750,000	5,534,984	2.93
Tomboy	U. S.	'13–'14	137,456	325,890	£62,000	452,000	5.07
Tom Reed	U. S.	'13–'14	48,100				8.06
Tonopah-Belmont	U. S.	'13–'14	172,398	2,006,091	1,650,000	357,623	9.06
Tonopah Extension	U. S.	'13–'14	58,022	80,399			9.25
Tonopah Mining	U. S.	'12–'14	163,387	1,363,441	1,200,000	172,761	7.41
Treasury Gold	Tran.	'12–'13	78,050	£4,880	£67,500		
Trethewey	Ont.	1913		130,697	150,000		
Trimountain	U. S.	1913	229,149	113,363	200,000		2.75
Troitsk Goldfield	Sib.	1913	39,500	−£5,523		22,430	
U. S. S. R. & M. Co.	U. S. and Mex.	1913	3,585,586		2,755,435		
Utah Apex	U. S.	'12–'14	121,675	54,561			
Utah Consol	U. S.	1913			450,000		
Utah Copper	U. S.	1913	7,519,392	5,795,513	4,747,710	268,000,000	1.00
Van Roi	B. C.	'12–'13	25,702	−£20,559			6.93
Van Ryn	Tran.	'12–'13	456,255	£248,255	£237,500	2,004,539	4.15
Victoria	U. S.	1913	137,163		None.		
Vindicator	U. S.	1913	33,517		180,000		
Vogelstruis Estate	Tran.	'12–'13	147,603	−£8,833		207,000	6.01
Waihi	N. Z.	1913	184,768	£108,375	£99,181	764,732	6.88
Waihi Grand Je	N. Z.	1913	98,383	£41,591	£19,219	175,100	
Wallaroo & Moonta	Aus.	½–1913	67,860				
Wanderer	Tran.	'13–'14	150,060	−£1,789		102,300	2.42
Wasp No. 2	U. S.	1914	176,140	45,465	30,000		1.20
West End Con	U. S.	1913	44,756	332,848	93 424		7.79
Wheal Kitty	Eng.	½–1913	7,630	£914	£349		6.72
Winona	U. S.	1914	123,339				
Witwatersrand Deep	Tran.	1913	451,000	£178,522	£137,500	1,492,257	4.85
Wolhuter	Tran.	'13–'14	382,700	£53,853	£107,500	999,400	4.47*
Wolverine	U. S.	'13–'14	182,127	81,075			2.21
Yukon Gold	Alas.	1913	+11,056,554	1,083,913	1,050,000		0.33
Zinc Corporation	Aus.	1913	162,966			971,784	

Note.—Abbreviations used in above table: Alas., Alaska; Aus., Australia; Bras., Brasil; Can., Canada; Cape, Cape Colonies; Cho., Chosen; Eng., British Isles (Cornwall); Hon., Honduras; Ind., India; Mal., Malay States; Mex., Mexico; N. S. W., New South Wales; N. Z., New Zealand; Port., Portugal; Rhod., Rhodesia; Russ., Russia; Sib., Siberia; S. Af., South Africa; Tas., Tasmania; Tran., Transvaal; U. S., United States; W. Af., West Africa.

−Loss for the year. + Cubic yards. *Working cost. All profits and dividends are in dollars except where otherwise noted.

AUSTRALASIA

In the following tables the production of minerals and metals in each of the Australian states and New Zealand is separately itemized. In the tables relating to foreign commerce, however, the states are not separately treated, the combined statistics of the Commonwealth now being officially reported. Figures in full-faced type are either provisional figures or estimates.

MINERAL PRODUCTION OF NEW SOUTH WALES (*a*)
(In metric tons or dollars; £1 = $5) (*b*)

Year.	Alunite.	Antimony and Ore.	Bismuth Ore.	Chrome Ore.	Coal.	Coke.	Cobalt Ore.	Copper Ore.
1900	1,946	252	11	3,338	5,595,879	128,238	145	867
1901	3,196	90	21	2,523	6,063,921	130,944	112	655
1902	3,702	58	10	508	6,037,083	128,902	35	3,190
1903	2,524	13	23	1,982	6,456,523	163,161	155	1,750
1904	376	111	41	404	6,116,126	173,742	6	2,470
1905	2,745	394	56	53	6,738,252	165,568	*Nil.*	487
1906	1,886	2,490	25	15	7,748,384	189,038	*Nil.*	(*g*)
1907	2,021	1,780	17	30	8,796,451	258,683	*Nil.*	(*g*)
1908	1,099	119	9	*Nil.*	9,293,377	288,413	*Nil.*	(*g*)
1909	3,556	97	9	*Nil.*	7,132,548	207,553	*Nil.*	(*g*)
1910	1,154	99	7	*Nil.*	8,304,693	286,854	10	(*g*)
1911	1,023	168	9	*Nil.*	8,831,175	268,935	*Nil.*	(*g*)
1912	3,479	64	6	*Nil.*	10,044,487	245,050	*Nil.*	(*g*)
1913	2,269	18	9	*Nil.*	10,587,734	303,585	*Nil.*	(*g*)
1914	3,089	37	15	*Nil.*	10,556,872	309,677	*Nil.*	(*g*)

Year.	Copper Matte, Ingot, and Regulus.	Diamonds. *Carats.*	Gold. (*b*)	Lead, Argentiferous. (*f*)		Lead, Pig. (*f*)	Molybdenite.	Opal.
				Ore.	Metal. (*e*)			
1900	6,243	9,828	$5,211,097	426,480	19,400	(*d*)6,807	.....	$400,000
1901	6,184	9,322	3,587,040	406,560	17,191	(*d*)3,394	.....	600,000
1902	5,560	11,995	3,333,064	371,496	15,660	(*d*)4,685	16	700,000
1903	8,094	12,239	5,255,421	335,870	18,779	(*d*)3,561	31	500,000
1904	6,654	14,296	5,576,966	373,362	30,212	(*d*)5,977	26	285,000
1905	7,899	6,354	5,669,099	420,266	28,244	214	20	295,000
1906	9,911	2,827	5,249,762	377,890	22,573	60	34	282,500
1907	10,260	2,539	5,112,852	441,024	20,687	20,084	22	395,000
1908	9,215	2,205	4,646,451	364,488	(*h*)	15,174	9	209,000
1909	7,078	5,474	4,231,211	273,628	(*h*)	15,724	29	309,000
1910	13,096	3,606	4,011,055	322,780	(*h*)	21,534	50	331,000
1911	12,295	5,771	3,743,672	343,902	(*h*)	17,552	21	286,500
1912	11,211	2,239	3,416,560	350,850	(*h*)	17,528	57	170,349
1913	9,619	5,573	3,093,331	397,783	(*h*)	23,947	80	143,513
1914	6,713	1,580	2,583,496	342,411	(*h*)	26,405	62	132,670

Year.	Platinum. Kg.	Oil Shale.	Silver. Kg. (f)	Tin.		Tungsten Ore.	Zinc. (c) (f)
				Ore.	Block.		
1900.....	15.6	23,229	24,080	15	1,087	.....	20,594
1901.....	12.1	55,650	13,950	11	659	.....	642
1902.....	11.6	63,886	33,195	23	502	.....	1,281
1903.....	16.5	35,332	34,195	556	949	9	21,086
1904.....	16.6	38,477	34,880	586	1,084	106	58,523
1905.....	12.4	38,838	12,987	726	817	228	105,189
1906.....	6.4	32,965	8,865	(h)	1,698	245	105,325
1907.....	8.6	48,088	63,573	(h)	1,945	409	241,015
1908.....	4.2	47,044	77,490	(h)	1,822	247	281,147
1909.....	13.7	49,500	53,430	(h)	1,974	129	379,907
1910.....	10.3	69,385	55,176	(h)	1,898	168	476,125
1911.....	14.6	76,306	54,975	(h)	1,960	288	524,666
1912.....	19.0	87,399	74,314	(h)	2,107	231	528,872
1913.....	13.7	17,268	68,267	(h)	3,071	172	515,105
1914.....	6.9	50,880	81,408	(h)	2,355	200	365,059

(a) From the Annual Report of the Department of Mines, New South Wales. (b) Where gold is reported, £1 = $4.866. (c) Spelter and concentrate. (d) Includes minor quantities of lead carbonate and chloride, the product of the leaching plant at Broken Hill. (e) Includes a small quantity of silver-sulphide. (f) Exported. In the case of lead, 101,811 long tons was produced in 1912 from N. S. Wales in Australia; see article on lead. (g) Included with metal. (h) Included with ore.

MINERAL PRODUCTION OF QUEENSLAND (a)

(In metric tons or dollars; £1 = $5)

Year.	Bismuth Ore.	Coal.	Copper.	Gold. (b)	Lead.	Manganese Ore.
1900.....	8	505,252	386	$20,002,290	207	77
1901.....	20	548,104	3,110	12,367,276	570	221
1902.....	1	509,579	3,845	13,238,500	271	4,674
1903.....	11	515,950	4,995	13,818,653	3,856	1,341
1904.....	20	520,232	4,440	13,210,869	2,079	843
1905.....	15	537,795	7,337	12,249,157	2,464	1,541
1906.....	7	610,480	10,238	11,257,316	2,854	1,131
1907.....	6	694,204	12,959	9,641,789	5,240	1,134
1908.....	22	707,473	14,932	9,613,051	7,207	1,403
1909.....	11	768,720	14,727	9,416,576	5,323	613
1910.....	22	885,108	16,649	9,123,531	2,435	805
1911.....	10	905,568	20,709	7,981,791	1,799	1,167
1912.....	(c)201	917,202	23,505	7,191,846	3,179	313
1913....	185	1,045,243	24,050	5,492,585	3,663	27
1914.....	197	1,071,237	18,738	5,156,919	736	6

Year.	Molybdenite.	Opal.	Silver. Kg.	Tin Ore.	Tungsten Ore.
1900.....	.....	$37,500	3,514	1,133	193
1901.....	.....	37,000	17,777	1,638	73
1902.....	(c) 42	35,000	21,813	2,118	56
1903.....	(c) 24	36,500	19,972	3,768	200
1904.....	(c) 22	17,750	20,370	3,986	1,564
1905.....	64	15,000	18,716	4,008	1,434
1906.....	108	15,000	24,357	4,900	785
1907.....	68	15,000	28,662	5,222	627
1908.....	89	12,500	36,200	4,903	426
1909.....	94	10,000	31,140	3,379	617
1910.....	108	15,000	26,787	3,000	889
1911.....	(c)232	15,000	17,076	3,140	548
1912.....	104	14,600	17,712	3,284	636
1913.....	68	14,600	18,817	4,251	364
1914.....	79	9,700	7,899	2,119	245

(a) From *Annual Reports* of the Under Secretary of Mines, Queensland. (b) Where gold is reported, £1 = $4.866. (c) Includes bismuth and some tungsten.

MINERAL PRODUCTION OF SOUTH AUSTRALIA
(In metric tons or dollars) (a)

Year.	Copper.		Gold. (b)	Iron Ore.	Lead.	Lime-stone.	Phosphate Rock.	Salt.	Other Metals and Minerals.
	Ore.	Metal.							
1901.....	1,896	6,844	$80,839	.....	69	.....	.....	.....	$11,095
1902.....	2,620	6,956	121,056	.....	2,210	.....	.....	.....	3,710
1903.....	7,182	6,594	139,411	86,291	732	.....	1,016	40,640	500
1904.....	3,100	6,378	369,938	47,434	.....	44,135	3,048	40,640	990
1905.....	2,604	6,653	223,121	85,835	53	45,210	5,080	33,020	6,305
1906.....	535	8,339	131,382	76,430	51	32,451	5,944	55,880	11,045
1907.....	.....	8,058	99,948	85,954	.....	31,598	8,128	76,200	12,500
1908.....	.....	5,718	59,852	89,412	.....	29,973	11,177	76,204	22,500
1909.....	1,250	5,788	146,982	16,379	142	13,986	3,833	52,232	19,365
1910.....	.....	5,184	136,248	46,939	406	18,898	5,283	54,862	68,000
1911 (a)..	.....	6,017	72,990	42,976	.....	29,159	5,893	66,040	56,600
1912.....	.....	6,395	136,248	42,877	.....	51,412	6,198	65,338	51,044
1913.....	.....	7,174	134,275	61,669	.....	45,038	6,049	66,083	104,906
1914.....	.....	6,996	129,363	43,324	.....	54,955	6,184	66,083	179,425

(a) From *Review of Mining Operations*, by Hon. Richard Butler, Adelaide, 1911. (b) Where gold is reported, £1 = $4.866.

MINERAL PRODUCTION OF TASMANIA (a)
(In metric tons or dollars) (b)

Year.	Coal.	Copper Ore.	Blister Copper.	Gold. (b)	Iron Ore.	Lead-Silver Ore.	Tin Ore.
1901.....	49,963	11,401	10,141	$1,436,326	1,422	804,463	2,516
1902.....	49,647	8,630	7,869	1,467,454	2,424	47,226	1,989
1903.....	49,856	3,891	6,791	1,237,925	6,076	43,103	2,414
1904.....	62,090	(d)	8,826	1,362,587	6,950	51,959	2,104
1905.....	52,825	(d)	9,919	1,520,101	6,401	76,424	3,953
1906.....	53,742	2,270	8,847	1,240,650	2,642	88,513	4,545
1907.....	59,833	1,261	8,378	1,350,836	3,048	91,216	4,412
1908.....	62,044	1,204	8,974	1,179,950	3,657	62,022	4,593
1909.....	67,224	1,613	8,472	951,005	*Nil.*	81,668	4,583
1910.....	83,763	682	8,324	765,784	*Nil.*	52,047	3,760
1911.....	57,980	2,323	6,118	628,375	*Nil.*	62,489	4,016
1912.....	54,366	1,414	5,218	784,320	*Nil.*	91,570	3,773
1913.....	55,960	2,000	4,645	690,369	*Nil.*	84,677	4,077
1914.....	61,807	3,343	7,634	542,437	*Nil.*	11,758	2,616

(a) From *Statistics of the Colony of Tasmania*. (b) Where value of gold is reported, £1 = $4.866. (c) Included with lead-silver ore. (d) Not reported.

MINERAL PRODUCTION OF NEW ZEALAND (a) (b)
(In metric tons or dollars) (c)

Year.	Anti-mony.	Chrome Ore.	Coal.	Coke.	Copper Ore.	Gold. (c)	Kauri-gum.	Manga-nese Ore.	Silver. *Kg.*
01...	30	.....	1,247,341	.....	3	$8,533,908	7,662	211	17,762.0
2...	- -	128	1,383,511	.....	.....	9,495,673	7,549	.....	20,970.3
3...	- -	.....	1,442,987	.....	6	9,916,086	9,507	71	28,364.3
4...	- -	.....	1,562,520	.....	.....	9,671,180	9,203	196	34,042.3
...	- -	.....	1,611,207	15	4	10,189,093	10,883	55	36,695.0
...	- -	.....	1,757,284	5	.....	11,050,219	9,300	16	43,251.5
...	100	.....	1,860,397	15	57	9,865,766	8,847	5	48,603.5
...	5	.....	1,890,844	2	13	9,755,303	5,618	*Nil.*	53,834.8
...	2	*Nil.*	1,941,923	23	5	9,765,575	8,382	6	56,410.0
...	*Nil.*	*Nil.*	2,232,610	*Nil.*	*Nil.*	9,227,532	8,832	5	52,176.8
...	20	*Nil.*	2,099,234	*Nil.*	*Nil.*	9,105,000	7,587	1	40,775.2
...	- -	.....	2,177,615	4	*Nil.*	6,427,422	7,908	.....	24,237.8
...	- -	.....	1,919,472	28	.....	7,101,822	8,926	.....	30,344.6

From New Zealand Mines Statement, by the Hon. Roderick McKenzie, Minister of Mines, ington. (b) The exports are stated to be identical with the production, with the exception of coal. Where gold is reported, £1 = $4.866.

Name of Mine.	Location.	Year.	Tonnage Produced.	Profits.	Dividends.	Ore Reserves, Tons.	Cost per Ton.
Selukwe-Columbia	Rhod.	'12-'13	37,263	£14,662	.....	.....	.....
Seoul Mining	Chosen.	1913	71,535	.....	500,000	592,418	4.13*
Shannon Copper	U. S.	1913	364,584	476,440	150,000	.....	.....
Sheba Gold	Tran.	'12-'13	68,920	£42,281	£47,204	110,000	8.31
Silver King Coalition	U. S.	'12-'13	100,225	.....	500,000	.....	10.50
Simmer & Jack Prop.	Tran.	'13-'14	769,900	£322,678	£337,500	2,320,000	3.00
Snowstorm	U. S.	1913	105,674	137,455	112,463	.....	.....
Sons of Gwalia	Aus.	1913	162,101	£66,277	£66,300	625,000	.....
South Crofty	Eng.	1914	69,342	£2,653	£4,375	.....	5.00
South Kalgurli	Aus.	'13-'14	124,670	£6,572	£6,250	.....	4.96
Spassky Copper	Sib.	1913	33,663	£226,318	£152,850	342,882	.....
Stewart	U. S.	1913	174,126	.....	561,434	.....	.....
St. John de Rev.	Brazil.	'13-'14	175,823	£128,676	£10,000	887,400	8.41
Sudan Goldfields	S. A.	1913	17,049	29,000	.....	42,862	.....
Sulphide Corporation	Aus.	'13-'14	209,074	£165,227	£200,000	.....	.....
Superior & Pittsburgh	U. S.	1914	485,796	.....	.....	.....	.....
Talisman Con.	N. Z.	'13-'14	41,680	.....	£120,750	37,515	13.78
Tamarack	U. S.	1913	227,563	-49,923	None.	.....	.....
Taqua Mining & Exp.	W. A.	'12-'13	61,607	£39,698	.....	198,502	.....
Tasmania Gold	Tas.	'12-'13	53,812	-£3,028	.....	.....	8.38
Tennessee Copper	U. S.	1913	470,135	.....	750,000	5,534,984	2.93
Tomboy	U. S.	'13-'14	137,456	325,890	£62,000	452,000	5.07
Tom Reed	U. S.	'13-'14	48,100	.....	.....	.....	8.66
Tonopah-Belmont	U. S.	'13-'14	172,398	2,006,091	1,650,000	357,623	9.86
Tonopah Extension	U. S.	'13-'14	58,022	80,399	.....	.....	9.25
Tonopah Mining	U. S.	'13-'14	163,387	1,363,441	1,300,000	172,761	7.41
Treasury Gold	Tran.	'12-'13	78,050	£4,880	£67,500	.....	.....
Trethewey	Ont.	1913	.....	130,697	150,000	.....	.....
Trimountain	U. S.	1913	229,149	113,363	200,000	.....	2.75
Troitzk Goldfield	Sib.	1913	39,500	-£5,523	.....	22,430	.....
U. S. S. R. & M. Co.	U. S. and Mex.	1913	3,585,586	.....	2,755,435	.....	.....
Utah Apex	U. S.	'13-'14	121,675	54,561	.....	.....	.....
Utah Consol.	U. S.	1913	.....	.....	450,000	.....	.....
Utah Copper	U. S.	1913	7,519,392	5,795,513	4,747,710	268,000,000	1.60
Van Roi	B. C.	'12-'13	25,702	-£20,559	.....	.....	6.90
Van Ryn	Tran.	'12-'13	456,255	£248,255	£237,500	2,004,529	4.15
Victoria	U. S.	1913	137,163	.....	None.	.....	.....
Vindicator	U. S.	1913	33,517	.....	180,000	.....	.....
Vogelstruis Estate	Tran.	'12-'13	147,603	-£8,833	.....	207,000	6.01
Waihi	N. Z.	1913	184,768	£108,375	£99,181	764,732	6.88
Waihi Grand Jc.	N. Z.	1913	98,383	£41,591	£19,219	175,100	.....
Wallaroo & Moonta	Aus.	½-1913	67,860	.....	.....	.....	.....
Wanderer	Tran.	'13-'14	150,060	-£1,789	.....	102,300	2.42
Wasp No. 2	U. S.	1914	176,140	45,465	30,000	.....	1.29
West End Con.	U. S.	1913	44,756	332,848	93 424	.....	7.79
Wheal Kitty	Eng.	½-1913	7,630	£914	£349	.....	6.72
Winona	U. S.	1914	123,339	.....	.....	.....	.....
Witwatersrand Deep	Tran.	1913	451,000	£178,522	£137,500	1,492,257	4.85
Wolhuter	Tran.	'13-'14	382,700	£53,853	£107,500	999,400	4.47*
Wolverine	U. S.	'13-'14	182,127	81,075	.....	.....	2.21
Yukon Gold	Alas.	1913	+11,056,554	1,083,913	1,050,000	.....	0.335
Zinc Corporation	Aus.	1913	162,966	.....	.....	971,784	.....

Note.—Abbreviations used in above table: Alas., Alaska; Aus., Australia; Braz., Brazil; Can., Canada; Cape, Cape Colonies; Cho., Chosen; Eng., British Isles (Cornwall); Hon., Honduras; Ind., India; Mal., Malay States; Mex., Mexico; N. S. W., New South Wales; N. Z., New Zealand; Port., Portugal; Rhod., Rhodesia; Russ., Russia; Sib., Siberia; S. Af., South Africa; Tas., Tasmania; Tran., Transvaal; U. S., United States; W. Af., West Africa.

-Loss for the year. + Cubic yards. *Working cost. All profits and dividends are *in dollars* except where otherwise noted.

Year.	Graphite. *Cwt.*	Iron and Steel.			Lead Mfrs. *Cwt.*	Petroleum Products.		
		Bars, Rods Girders, Sheets, etc. *Cwt.*	Galvanized Plates and Sheets. *Cwt.*	Pig and Scrap. *Cwt.*		Kerosene. *Gal.*	Naphtha. *Gal.*	Paraffin.
1903..	5,557	1,211,437	886,570	989,998	9,525	15,009,609	127,445	2,163
1904..	4,263	1,399,783	1,027,859	883,397	6,243	14,791,319	277,737	530
1905..	4,386	1,482,334	1,112,467	940,757	8,859	16,416,734	292,670	.....
1906..	6,531	1,878,851	1,245,211	1,220,236	14,830	15,473,570	488,961	.....
1907..	6,991	2,045,184	1,502,790	1,276,566	2,940	19,273,955	683,679	2,578
1908..	.....	2,153,528	(*d*)1,253,624	820,834	2,703	17,154,940	782,859	1,560
1909..	.....	2,559,798	(*d*)1,658,291	1,178,219	19,338	19,924,622	884,703	2,767
1910..	£9,951	3,663,386	2,131,911	1,073,933	9,111	19,660,890	1,339,381	3,963
1911..	£7,782	4,212,986	2,177,961	1,574,439	1,820	19,378,540	1,772,840	3,314
1912..	£8,629	4,933,414	2,416,367	1,719,585	1,194	24,292,539	12,294,617	2,832
1913..	£9,578	5,070,590	2,196,865	1,535,030	2,075	19,288,122	8,812,771	2,793

Year.	Potassium Nitrate. *Cwt.*	Quick-silver.	Salt. *Cwt.*	Silver. (*b*)			Sulphur. *Cwt.*	Spelter, Sheets, Concentrates, Dross, etc. *Cwt.*
				Ore. *Cwt.*	Bullion. *Kg.*	Specie.		
1903.....	4,659	87.5	312,681	.....	14.2	160,111	180,719	14,197
1904.....	7,812	92.6	355,599	.....	39.8	154,534	252,744	23,316
1905.....	9,010	82.1	492,727	.....	3908.0	261,397	177,304	26,211
1906.....	8,112	78.6	326,042	380	9756.4	703,820	269,704	24,233
1907.....	8,571	59.5	409,852	2	11.4	1,829,309	264,060	24,026
1908.....	6,036	56.4	390,535	.....	189.8	1,019,738	420,098	38,724
1909.....	6,894	58.1	234,092	.....	622.1	157,352	405,396	59,475
1910.....	7,016	57.0	444,081	14,609	1,412.0	1,615,775	357,332	70,658
1911.....	10,257	41.5	753,849	17,340	1,580.3	1,647,830	386,764	86,601
1912.....	10,127	53.0	475,967	3,863	1,580.3	1,350,870	465,643	29,245
1913.....	10,552	460.0	533,055	10,396	10,763.0	861,500	560,065	9,437

(*a*) From Trade and Customs Returns, Commonwealth of Australia. Previous to 1900 each Colony reported its own imports and exports. (*b*) Where gold or silver values are reported, £1 = $4.866. (*c*) Includes silver and other foils. (*d*) Includes ungalvanized corrugated. (*e*) Includes $19,000 in matte.

MINERAL EXPORTS OF AUSTRALIA (*a*)

(In metric tons, cwt. of 112 lb., or dollars; £1 = $5)

Year.	Alunite. *Cwt.*	Anti-mony Ore. *Cwt.*	Bis-muth Ore. *Cwt.*	Cement. *Cwt.*	Chrome Ore. *Cwt.*	Coal.	Coke.	Co-balt Ore. *Cwt.*	Copper.	
									Ore. *Cwt.*	Ingot and Matte. (*Cwt.*)
1903.	49,690	947	832	11,168	39,022	2,063,016	27,345	3,060	61,569	616,277
1904.	7,400	2,177	1,918	26,305	7,941	1,637,113	2,771	167	90,098	540,998
1905.	54,040	7,811	2,222	17,283	(*c*)	2,058,190	2,316	1,320	17,380	632,183
1906.	37,120	66,188	1,574	39,737	(*c*)	2,094,793	11,382	.....	33,476	744,357
1907.	41,750	74,440	653	75,600	54,503	2,689,917	35,063	.....	157,071	853,236
1908.	21,640	23,931	1,396	49,116	22,300	2,601,944	28,068	.....	103,694	765,298
1909.	73,795	14,976	1,763	23,585	.....	1,608,161	24,798	280	163,612	676,664
1910.	23,290	12,796	1,456	34,259	.....	1,730,375	10,457	186	209,611	769,745
1911.	20,272	17,985	2,307	45,247	.....	1,714,947	8,492	.....	263,078	806,005
1912.	68,500	30,894	610	27,724	453	2,186,930	9,852	.....	(*f*)295,751	876,773
1913.	44,700	51,007	588	18,221	.....	2,129,982	8,154	.....	177,757	846,411

Year.	Gold. (b)				Iron and Steel Bars, Rods, etc. Cwt.	Lead.		
	Ore.	Bullion.	Specie.	Total Value.		Pig and Matte. Cwt.	Argentiferous. Cwt.	Manufactures Cwt.
1903....	80,591	$29,691,889	$53,634,629	$83,407,109	5,753	633,816	553,308	28,783
1904....	46,894	27,073,767	49,284,833	76,405,494	4,952	1,626,292	790,435	20,552
1905....	49,507	25,788,574	27,523,288	53,361,369	4,821	1,302,428	753,008	34,629
1906....	20,296	24,113,950	47,937,681	72,071,927	11,560	1,031,605	781,426	20,358
1907....	17,513	(e) 19,639,502	33,370,240	53,027,255	13,163	1,774,207	.....	21,765
1908....	20,539	(e) 18,924,716	50,794,544	69,739,799	13,015	2,132,199	.....	20,161
1909....	270,131	(e) 17,265,872	26,028,555	43,564,558	12,040	1,381,369	.....	14,067
1910....	429,288	(e) 11,970,906	10,598,747	22,998,940	17,106	1,800,856	845,856	13,350
1911....	327,101	10,456,322	47,831,267	58,614,700	117,131	1,755,650	430,073	14,610
1912....	340,474	(e) 9,135,487	50,801,322	60,277,283	134,201	1,438,681	502,264	17,916
1913....	1,164,146	6,695,757	10,184,007	18,043,910	187,330	1,529,075	524,513	14,989

Year.	Molybdenum Ore. Cwt.	Salt. Cwt.	Shale. Oil.	Silver.		Tin.		Spelter, Sheets, Concentrates, Dross, etc. Cwt.
				Ore. (d) Cwt.	Bullion. Kg.	Ore. Cwt.	Block. Cwt.	
1903.....	783	155,613	14,483	1,653,794	202,730	26,900	82,473	60,206
1904.....	1,100	141,553	8,202	2,235,385	227,972	40,339	99,476	309,422
1905.....	1,381	174,987	11,818	581,651	208,134	55,153	108,963	3,006,372
1906.....	1,867	198,851	7,203	1,010,707	174,457	51,793	130,120	2,592,018
1907.....	2,025	189,194	5,686	907,790	294,679	65,005	131,407	5,393,784
1908.....	2,116	240,348	19,173	1,137,746	326,250	49,409	121,979	6,235,024
1909.....	1,055	230,486	3,983	1,914,479	90,989	8,559	111,262	6,994,745
1910.....	1,972	184,892	9,307	(f) 2,524,487	137,916	40,469	87,529	8,161,081
1911.....	1,876	63,607	6,344	(f) 3,226,043	(e)218,388	(f)55,721	82,935	8,648,818
1912.....	2,873	123,779	290	(f) 2,395,267	(e)217,820	(f)64,704	77,501	9,265,599
1913.....	2,684	134,868	449	(d)(f)3,377,901	(e)229,940	89,384	68,392	9,549,433

(a) From Trade and Customs Returns, Commonwealth of Australia.—Note. Previous to 1900 each Colony reported its own exports separately. (b) Where gold or silver values are reported, £1 = $4.866. (c) Included with iron ore. (d) Includes lead ore. (e) Includes that contained in matte. (f) Includes concentrates.

AUSTRIA-HUNGARY

the following tables the mineral and metal productions of the two gdoms are reported separately, together with that of Bosnia and egovina. Exports and imports are reported jointly.

MINERAL AND METALLURGICAL PRODUCTION OF AUSTRIA (a)
(In metric tons)

ar.	Alum.	Alum and Pyritic Shale.	Antimony.		Asphaltic Rock.	Bismuth Ore.	Coal.	
			Ore.	Metal.			Bituminous.	Lignitic.
.....	620	3,004	201	153	887	4.0	10,992,515	21,539,917
.....	442	2,551	126	114	541	16.0	11,738,840	22,473,510
.....	62	2,866	18	24	897	8.0	11,045,039	22,139,683
.....	*Nil*	2,978	41	14	1,273	10.0	11,498,111	22,157,521
.....	*Nil*	2,337	103	36	1,435	1.7	11,868,245	21,987,651
.....	*Nil*	1,657	1,673	90	4,363	1.7	12,585,263	22,692,076
.....	*Nil*	1,020	1,071	*Nil*	2,840	2.7	13,473,307	24,167,714
.....	*Nil*	*Nil*	910	207	3,858	*Nil*	13,850,420	26,262,110
.....	*Nil*	*Nil*	193	162	3,695	*Nil*	13,875,382	26,728,926
.....	*Nil*	*Nil*	450	*Nil*	2,975	*Nil*	13,713,043	26,043,716
.....	*Nil*	*Nil*	225	*Nil*	1,066	*Nil*	14,056,858	25,157,541
.....	*Nil*	*Nil*	270	.....	1,740	4.0	14,487,550	25,152,601
.....	.....	.....	4,520	13	4,234	.....	15,797,890	26,283,690
.....	.....	.....	1,270	.....	3,026	.....	16,459,889	27,378,332

ar.	Copper.			Copperas.	Gold.		Graphite.	Iron.	
	Ore.	Metal.	Sulphate.		Ore.	Bullion.		Ore.	Pig & Cast.
.....	5,825	881	234	474	$227	$47,183	33,663	1,894,458	879,132
.....	7,406	776	256	472	143	31,234	29,992	1,963,246	884,844
.....	8,455	914	248	271	74	4,652	29,527	1,742,498	991,827
.....	12,688	961	310	298	2,148	5,316	29,590	1,715,984	970,832
.....	10,701	889	808	414	12,653	47,183	28,620	1,719,219	988,364
.....	10,677	870	540	116	35,937	133,218	34,416	1,913,782	1,119,614
.....	20,255	877	578	154	33,033	83,401	38,117	2,253,662	1,222,230
.....	10,400	592	579	*Nil*	30,711	92,471	49,425	2,540,118	1,383,524
.....	8,381	683	556	*Nil*	28,907	98,504	44,425	2,632,407	1,466,897
.....	11,826	985	591	70	29,709	98,295	40,710	2,490,277	1,465,051
.....	8,005	1,468	715	*Nil*	31,744	118,895	33,131	2,627,513	1,504,786
.....	10,974	1,760	767	*Nil*	29,647	134,840	41,599	2,765,815	1,596,148
.....	17,354	3,057	884	40	30,192	134,543	45,375	2,926,686	1,759,850
.....	16,353	3,685	897	40	35,994	186,714	49,456	3,039,324	1,757,864

.	Lead.			Manganese. Ore.	Mineral Paint.	Petroleum.	Quicksilver.		Salt.
	Ore.	Pig.	Litharge.				Ore.	Metal.	
....	14,314	10,650	1,288	8,804	2,828	347,213	94,747	510	330,277
....	16,688	10,161	1,317	7,796	1,701	404,662	97,360	525	333,238
....	19,055	11,264	1,023	5,646	1,486	520,845	90,040	511	311,806
....	22,196	12,162	923	6,179	1,691	672,508	83,321	523	359,015
....	22,514	12,645	783	10,189	1,829	.....	88,279	536	369,877
....	23,339	12,968	865	13,788	798	.....	86,856	520	343,375
....	19,683	14,846	1,059	13,402	943	.....	91,494	526	378,912
....	22,792	13,598	863	16,756	1,091	.....	89,370	527	395,053
....	21,513	12,669	1,010	16,656	475	.....	90,145	572	388,133
....	20,550	12,941	840	18,045	620	.....	92,337	585	359,801
....	22,841	15,476	602	15,694	698	1,766,018	100,899	603	345,629
....	23,845	18,097	318	15,954	2,902	1,487,842	111,018	704	342,732
....	27,952	19,993	301	12,471	2,960	1,144,133	117,780	763	365,789
....	25,751	22,312	305	16,540	2,999	1,081,090	130,608	820	327,830

Year.	Silver.		Sulphuric Acid.	Sulphur. Ore.	Tin.		Tungsten Ore.	Uranium.		Zinc.	
	Ore.	Bullion. Kg.			Ore.	Block.		Ore.	Salts.	Ore.	Spelter.
1900.	21,641	39,572	7,067	862	51	40	50	52.0	11.3	38,243	6,742
1901.	21,363	40,205	7,073	4,911	42	49	45	48.0	13.0	36,072	7,558
1902.	22,288	39,544	8,781	3,721	47	50	45	46.0	10.0	31,927	8,309
1903.	21,958	39,812	9,105	4,475	57	34	49	45.0	6.0	29,544	8,949
1904.	21,949	39,032	8,742	6,288	77	38	52	17.0	11.0	29,226	9,159
1905.	21,047	38,453	1,007	8,407	52	53	55	16.0	13.9	29,983	9,326
1906.	21,944	38,940	745	15,125	55	42	56	16.0	16.1	32,037	10,804
1907.	22,636	38,742	*Nil*	24,099	53	47	44	11.0	11.2	31,970	11,208
1908.	22,241	39,867	*Nil*	17,429	68	39	37	9.0	8.4	31,266	12,770
1909.	21,102	39,002	*Nil*	12,725	36	52	39	13.0	10.2	33,955	11,688
1910.	23,629	49,692	.....	15,839	37	40	40	6.5	10.3	34,637	12,458
1911.	24,143	50,244	.....	15,805	944	15	45	5.8	6.8	32,166	15,766
1912.	21,794	49,355	.....	13,996	606	13	66	11.0	5.0	34,675	17,298
1913.	19,937	54,434	.....	10,561	939	11	52	11.2	4.5	34,225	19,508

(a) From the *Statistisches Jahrbuch des K. K. Ackerbau-Ministeriums.*

MINERAL AND METALLURGICAL PRODUCTION OF HUNGARY (a)
(In metric tons or dollars; 1 crown = $0.203)

Year.	Antimony.		Asphalt	Asphaltic Rock.	Bismuth.	Carbon Bisulphide.	Coal.			
	Ore.	Regulus.					Bituminous. (d)	Lignite. (d)	Coke.	Briquets.
1900...	2,373	846	2,700	.....	2.0	1,250	1,447,047	5,128,277	12,973	69,353
1901...	(b) 323	706	2,878	25,161	1.6	2,087	1,365,270	5,179,829	10,975	40,182
1902...	(b) 748	683	2,774	24,873	0.9	2,320	1,162,785	5,132,053	8,204	88,069
1903...	(b) 205	732	2,422	21,552	1.5	2,357	1,233,410	5,271,781	9,442	101,197
1904...	1,080	1,007	2,221	17,660	0.9	2,512	1,155,320	5,519,349	5,103	103,481
1905...	949	756	173	19,372	1.4	2,760	919,193	6,015,452	69,303	144,697
1906...	1,807	954	4,111	34,664	2.0	2,756	1,103,529	6,229,712	79,930	151,657
1907...	2,035	841	3,920	33,096	0.4	2,950	1,038,819	6,408,322	97,447	154,783
1908...	1,316	670	4,818	72,972	(c)	2,966	982,017	7,034,499	141,954	109,178
1909...	1,971	695	5,054	.....	.....	3,086	1,397,424	7,658,719	157,415	117,594
1910...	1,939	782	4,994	.....	.....	3,245	1,302,103	7,734,166	156,048	108,873
1911...	2,616	892	3,861	.....	.....	3,488	1,290,182	8,154,560	145,104	118,412
1912...	8,380	859	4,460	.....	.....	3,692	1,302,405	8,287,871	149,913	118,505
1913...	11,017	1,038	3,024	45,860	(f)25	3,147	1,319,918	8,954,133	160,072	117,186

Year.	Copper.	Copperas.	Gold.	Iron.			Lead.		Litharge.	Manganese. Ore.
				Ore. (d)	Pig.	Cast.	Ore.	Pig.		
1900...	181	700	$2,173,079	1,666,363	432,817	22,738	612	2,030	201	5,746
1901...	162	805	2,189,692	1,557,300	430,686	20,640	(b) 10	2,029	238	4,591
1902...	89	909	2,260,135	1,562,238	416,835	18,569	(b) 20	2,244	219	7,237
1903...	45	982	2,243,521	1,439,132	396,674	18,875	(d)3,698	2,057	257	5,311
1904...	63	1,277	2,437,988	1,524,036	370,297	17,203	(d)3,922	2,104	710	11,527
1905...	73	920	2,439,451	1,661,358	403,719	17,563	686	2,146	209	5,708
1906...	69	1,306	2,487,156	1,698,291	402,527	17,164	564	1,925	698	7,176
1907...	85	1,212	2,330,292	(e)622,518	423,134	17,103	8	1,468	441	8,198
1908...	166	1,372	2,189,801	(e)727,019	505,559	17,415	3	1,544	190	10,601
1909...	265	1,414	1,813,024	1,965,487	514,853	15,577		1,590	625	11,921
1910...	214	1,313	2,022,032	1,905,749	487,421	14,635	91	2,077	570	13,270
1911...	208	849	2,125,241	1,950,231	502,460	15,990	239	1,583	391	14,755
1912...	242	1,364	1,898,771	1,991,162	541,659	11,180	1,212	1,605	328	13,833
1913...	404	627	1,945,972	2,059,075	608,965	13,985	.....	1,136	411	19,005

ear.	Mineral Paints.	Petroleum.	Pyrite.	Quicksilver. *Kg.*	Salt.	Silver. *Kg.*	Sulphur.	Sulphuric Acid.	Zinc.	
									Ore.(*b*)	Spelter.
...	305	3,296	93,907	33,003	215,581	23,636	137	1,464	693	14
...	283	4,347	106,490	44,600	217,079	23,020	105	1,193	364	.....
...	263	3,010	96,619	43,700	214,536	19,281	135	1,543	46	26
...	273	2,134	97,148	45,169	230,943	16,352	143	1,329	203	.....
...	196	471	106,848	36,000	238,642	15,946	135	1,410	173	.....
...	221	2,692	112,623	50,100	245,402	13,642	133	1,457	243	146
...	259	2,404	99,503	40,400	(*c*)	12,695	(*c*)	1,232	(*c*)	(*c*)
...	294	2,427	95,824	78,000	(*c*)	12,612	144	1,444	135	(*c*)
...	63	2,590	98,971	71,500	231,182	10,932	131	1,307	(0)	.....
...	55	2,501	92,464	90,000	230,315	12,547	128	1,334	280	.....
...	69	2,191	96,755	79,700	239,006	10,806	51	938	106	.....
...	105	2,793	103,809	84,979	270,929	10,782	83	1,311	777	.....
...	57	2,104	106,629	88,800	301,805	8,696	41	.....	406	.....

) From the *Annuaire Statistique Hongrois.* (*b*) Includes only that part of the crude output that not smelted into a refined product. (*c*) Not reported. (*d*) Total production. (*e*) Exported. Kilograms.

ERAL AND METALLURGICAL PRODUCTION OF BOSNIA AND HERZEGOVINA (*a*)

(In metric tons)

r.	Chrome Ore.	Copper.		Iron.		Lignite.	Manganese Ore.	Pyrite.	Quicksilver.	Salt.
		Ore.	Metal.	Ore.	Pig.					
...	505	3,696	199	122,569	39,296	445,007	6,346	4,570	9.3	16,865
...	270	3,657	166	133,348	43,992	424,753	5,760	5,170	7.2	17,348
...	147	1,073	191	114,059	39,833	467,962	4,538	6,589	8.1	18,459
...	279	640	115	127,297	47,678	483,617	1,114	10,412	8.1	18,021
...	186	670	39	122,540	43,074	540,237	4,129	19,045	10.0	(*b*)
...	320	765	25	136,513	45,660	594,172	7,651	11,347	5.1	22,671
...	310	245	*Nil.*	150,684	48,946	621,179	7,000	7,229	1.2	21,148
(*c*)	315	(*b*)	*Nil.*	150,075	48,900	630,500	6,000	(*b*)	*Nil.*	22,100
(*c*)	310	(*b*)	*Nil.*	145,200	48,850	675,400	5,000	(*b*)	*Nil.*	22,500
...	320	(*b*)	*Nil.*	132,720	48,841	706,659	4,000	571	*Nil.*	23,579
...	250	(*b*)	*Nil.*	140,283	44,354	769,763	3,600	3,118	*Nil.*	22,591
...	200	.....	*Nil.*	150,420	53,270	852,920	4,650	6,216	*Nil.*	23,124
...	305	.....	.....	220,131	53,587	841,140	4,700	7,701	.....	24,176

) From *Oestr. Zeit. f. B.-u. H.* (*b*) Not reported. (*c*) Estimated.

MINERAL IMPORTS OF AUSTRIA-HUNGARY (*a*)

(In metric tons or dollars; 5 Crowns = $1)

ear.	Alum.	Aluminium and Alloys.	Aluminium Sulphate and Chloride.	Antimony.		Arsenic. (*b*)	Asbestos.	
				Ore.	Regulus. *Kg.*		Crude. (*c*)	Manufactures.
.....	430	154	1,435	46	23,000	320	1,085	1,238
.....	413	153	1,882	27	1,500	351	1,678	1,032
.....	537	151	2,161	40	18,200	351	2,038	798
.....	508	150	2,670	42	87,200	371	3,395	1,221
.....	602	231	2,346	64	21,000	384	2,517	1,240
.....	774	477	2,775	42	24,700	342	5,962	208
(*d*) ..	513	216	2,340	79	38,900	83	7,025	111
.....	545	255	3,200	231	89,900	325	5,729	180
.....	567	323	2,606	304	128,200	349	9,484	139
.....	359	418	1,831	95	80,100	370	12,003	200
.....	589	303	1,474	96	121,800	416	11,602	250
.....	375	516	1,317	98	124,600	377	16,071	276
.....	253	1,224	1,396	91	49,000	24	24,615	338
.....	454	589	1,334	.....	.....	47	17,575	248

Year.	Asphalt.		Barytes.	Borax.		Cement.	Chloride of Lime.	Chrome Ore.
	Crude Rock.	Mastic and Bitumen.		Crude, and Boric Acid.	Refined.			
1900.....	8,301	1,564	5,945	3,056	93	25,747	3,326	2,823
1901.....	5,702	1,106	6,336	1,687	233	23,559	3,326	860
1902.....	5,732	1,273	6,266	2,168	174	18,658	2,596	2,668
1903.....	5,871	1,272	7,057	2,192	150	23,256	2,791	2,121
1904.....	8,211	1,064	6,238	2,752	142	20,259	3,407	1,209
1905.....	8,553	1,139	6,187	3,099	205	21,950	1,847	2,305
1906(f).....	13,381	895	9,654	3,519	126	21,833	2,491	1,612
1907.....	9,394	1,637	11,669	3,763	138	23,697	2,534	2,795
1908.....	11,678	1,305	11,241	4,105	158	39,135	2,395	1,837
1909.....	9,113	1,309	13,940	3,240	139	53,262	3,105	2,223
1910.....	15,897	1,101	21,486	5,284	166	81,251	1,885	1,271
1911.....	18,394	1,990	20,501	4,407	193	80,613	3,131	2,217
1912.....	25,111	4,295	21,375	4,286	482	83,630	2,802	4,329
1913.....	24,794	1,011	23,350	5,652	356	61,261	3,097	2,845

Year.	Kaolin and Feldspar.	Coal.		Coke.	Copper.			Copper Sulphate.
		Bituminous.	Lignitic.		Ore.	Bullion and Scrap.	Bars, Sheets, Wire, etc.	
1900.....	6,847	6,242,939	67,740	620,776	16	18,970	121	3,516
1901.....	7,687	5,827,332	22,253	612,209	112	17,504	83	2,822
1902.....	9,085	5,766,377	29,601	547,406	100	18,498	149	2,839
1903.....	9,940	5,907,660	30,007	519,281	209	18,701	89	3,526
1904.....	10,854	6,190,030	30,001	548,272	1,107	22,532	89	4,508
1905.....	13,656	6,418,042	36,000	554,147	1,397	22,652	73	3,791
1906 (f)...	13,219	5,942,897	17,464	406,088	267	20,943	481	1,597
1907.....	17,961	9,692,645	23,699	677,750	44	26,181	818	3,981
1908.....	17,417	9,995,415	30,433	851,099	121	33,270	1,140	8,402
1909.....	16,185	10,482,264	38,679	701,281	13	30,606	568	4,129
1910.....	17,817	9,864,462	37,867	670,089	49	32,217	926	3,445
1911.....	22,828	10,873,799	34,381	702,707	716	37,251	538	6,598
1912.....	24,628	11,848,535	34,871	(h)915,547	765	45,460	850	16,131
1913.....	22,467	13,689,149	33,097	933,669	150	36,451	572	6,937

Year.	Copperas.	Cryolite.	Fluorspar.	Gold. (d)		Graphite.	Gypsum.		Hydrochloric Acid.
				Bullion.	Coin.		Crude.	Burned.	
1900.....	343	342	5,649	$1,111,831	$7,230,251	302	1,348	15,462	577
1901.....	269	428	5,774	13,865,103	20,353,592	318	1,405	15,830	576
1902.....	274	447	5,902	14,509,019	15,695,960	221	1,588	16,430	588
1903.....	155	521	5,445	9,825,200	9,817,283	405	1,969	18,655	603
1904.....	238	313	7,061	12,703,740	8,586,394	423	2,384	19,387	459
1905.....	169	220	7,601	1,047,792	9,204,968	735	1,553	21,286	656
1906(f)..	186	217	7,795	989,604	5,229,591	854	4,104	10,308	476
1907.....	187	613	8,779	1,106,002	5,755,918	934	5,813	11,981	629
1908.....	74	564	7,359	7,303,982	7,969,538	755	4,993	10,842	924
1909.....	56	556	8,106	36,744,037	8,631,453	660	4,907	10,410	898
1910.....	89	703	8,292	1,399,400	4,485,600	1,124	5,733	20,390	635
1911.....	66	944	9,446	3,163,554	1,902,798	1,173	6,616	16,489	612
1912.....	43	1,053	6,396	667,350	1,516,911	1,834	10,585	24,944	1,115
1913.....	53	635	10,204	5,855,085	3,626,938	1,499	8,696	24,659	975

Year.	Iron.				Lead.				
	Ore.	Pig and Old.	Manufactures.	Iron and Steel Bars, Sheets, Wire, etc.	Ore.	Pig, Alloys, Crude.	Litharge.	Red and Yellow.	White.
1900	233,156	95,530	$4,533,599	10,313	501	7,916	141	354	106
1901	218,476	90,287	4,443,670	10,902	1,270	10,722	189	433	135
1902	197,525	43,314	4,304,818	11,584	1,879	8,706	149	428	221
1903	217,979	47,354	4,508,224	11,025	1,355	9,190	141	423	173
1904	182,515	35,091	4,976,342	9,402	1,436	7,917	146	372	138
1905	228,149	49,383	5,722,976	33,256	247	7,282	101	349	88
1906(f)	232,558	57,341	6,153,698	5,085	189	11,732	82	310	75
1907	390,322	151,848	(g)29,520	29,268	204	12,547	98	381	126
1908	423,940	224,740	(g)45,235	88,396	559	17,116	161	616	201
1909	374,088	147,459	(g)48,344	34,025	7,560	20,697	230	599	57
1910	307,190	185,604	51,869	44,277	6,354	17,065	411	574	139
1911	469,552	112,907	53,590	32,687	1,200	17,238	299	622	108
1912	628,867	244,532	64,621	48,137	3,240	16,961	403	448	94
1913	942,312	188,324	.....	.....	8,055	12,455	402	367	113

Year.	Magnesium Chloride.	Manganese Ore.	Millstones.	Mineral Paints.	Nickel, Old and Crude.	Nickel and Cobalt Ores	Nitric Acid.	Peat and Peat Coke.
1900	2,100	7,016	1,672	4,958	258	406	36	2,664
1901	2,529	6,367	1,595	5,109	277	788	22	2,896
1902	2,621	15,595	1,410	4,831	265	225	90	3,234
1903	3,118	38,529	1,395	4,733	268	385	7	3,097
1904	2,997	35,357	1,282	5,563	402	656	24	2,676
1905	3,495	30,483	1,467	6,018	632	391	14	2,432
1906(f)	4,050	33,406	1,176	4,660	773	*Nil.*	12	1,918
1907	5,006	70,067	1,469	6,043	1,192	*Nil.*	12	4,460
1908	5,011	31,023	1,474	5,909	1,521	114	11	6,459
1909	6,095	44,970	1,357	5,773	2,116	*Nil.*	30	5,993
1910	6,616	59,951	1,510	7,340	1,606	*Nil.*	37	5,002
1911	7,171	78,790	1,494	7,157	1,598	0.1	27	5,115
1912	8,344	62,202	2,175	8,468	2,508	1.8	54	6,356
1913	7,799	67,278	2,066	6,984	1,895	.....	39	4,264

Year.	Petroleum Products.			Phosphorus and Phosphoric Acid.	Potassium Salts.			Pyrite.
	Crude Oil.	Refined Oil.	Paraffin.		Carbonate.	Chloride.	Chromate.	
1900	20,813	22,963	5,080	204	1,029	3,633	11	60,317
1901	22,545	18,067	5,294	222	1,442	4,356	21	54,202
1902	24,830	15,864	4,238	225	485	3,377	11	60,235
1903	19,710	19,382	2,598	237	197	3,727	9	73,835
1904	20,110	22,715	1,470	193	222	3,557	3	65,397
1905	18,974	24,961	888	222	154	3,864	5	86,338
1906(f)	13,522	9,693	403	178	602	3,729	(e) 5	87,973
1907	18,345	11,441	524	219	174	4,807	(e)38	130,270
1908	3,118	9,705	358	234	324	5,009	(e)98	130,793
1909	1,357	9,093	508	231	314	4,782	(e)86	141,858
1910	18,977	16,868	457	253	185	5,052	69	153,106
1911	19,070	19,737	632	233	201	3,666	55	150,974
1912	17,874	21,153	546	258	339	5,280	55	186,690
1913	19,125	31,590	299	255	157	5,216	175	130,526

Year.	Quicksilver Kg.	Salt.	Sand.	Silver.		Slag and Slag Wool.	Roofing Slate.
				Bullion. Kg.	Specie.		
1900.....	1,300	39,822	77,930	29,300	$199,955	.....	13,047
1901.....	2,600	39,625	83,401	41,800	207,669	.....	11,555
1902.....	1,300	46,128	92,617	177,900	237,104	.....	14,378
1903.....	1,600	48,793	94,492	150,400	250,299	.....	11,531
1904.....	2,500	94,103	97,364	36,700	420,413	.....	9,170
1905.....	2,400	.....	104,195	36,100	143,152	.....	8,852
1906(f).....	1,800	32,182	134,526	43,000	200,754	109,827	6,020
1907.....	1,200	41,660	180,280	88,182	170,228	107,783	7,537
1908.....	2,000	54,525	177,529	96,700	101,265	115,445	7,178
1909.....	2,600	75,397	183,169	150,980	172,201	155,812	6,915
1910.....	2,300	96,936	188,762	161,600	121,000	147,192	9,019
1911.....	2,900	99,921	225,743	195,000	70,102	147,179	8,060
1912.....	3,700	113,287	249,766	91,110	78,361	204,946	7,824
1913.....	4,400	110,923	235,775	148,580	206,032	214,726	6,351

Year.	Sodium Salts.						Sulphur.
	Bi-sulphate.	Carbonate.	Carbonate (Calcined).	Hydrate.	Nitrate.	Sulphate.	
1900 ..	73	104	1,141	1,836	54,559	5,110	27,795
1901 ..	98	77	911	1,280	63,283	4,452	25,300
1902 ..	17	97	312	1,030	39,958	5,997	23,878
1903 ..	13	110	327	956	54,896	6,116	22,625
1904 ..	103	103	1,109	659	54,887	5,409	30,505
1905 ..	167	168	965	475	66,740	5,258	30,227
1906(f)	86	382	303	218	49,862	7,508	26,755
1907 ..	72	153	283	305	57,023	7,342	34,261
1908 ..	32	124	288	358	69,722	7,596	30,985
1909 ..	26	149	297	832	80,533	9,402	28,639
1910 ..	15	224	354	341	81,781	10,150	34,936
1911 ..	5	297	337	297	65,781	10,842	34,916
1912 ..	10	(i)455	260	302	92,838	14,454	40,913
1913 ..	12	247	262	102	93,025	12,682	39,228

Year.	Sulphuric Acid.	Tin. Ingot, Crude, Old, etc.	Whet-stones.	Zinc.			
				Calamine and Other Ores.	Spelter.	Bars, Sheets, Wires, etc.	White.
1900.....	10,643	3,439	3,643	14,181	17,844	667	875
1901.....	11,712	3,671	3,445	18,403	16,921	579	718
1902.....	12,474	3,638	3,599	20,723	17,034	651	636
1903.....	16,148	3,564	3,774	22,344	17,973	746	606
1904.....	19,878	3,528	4,272	24,039	20,787	731	840
1905.....	17,320	3,845	4,376	22,890	21,874	568	972
1906(f).....	17,020	3,320	4,377	24,014	19,467	595	347
1907.....	20,430	4,433	5,552	24,289	24,092	604	219
1908.....	25,251	4,295	5,916	19,366	26,472	1,010	361
1909.....	27,368	4,587	6,826	24,639	27,148	1,263	349
1910.....	27,421	4,674	6,915	30,880	29,168	1,898	511
1911.....	26,630	4,795	8,066	31,357	33,740	388	471
1912.....	36,714	4,806	6,826	35,376	37,558	1,260	438
1913.....	24,922	4,214	6,579	52,299	31,841	1,264	392

(a) From *Statistik des Auswaertigen Handels des Oesterreichisch-Ungarischen Zollgebiets.* (b) Includes arsenious acid and sulphide. (c) Includes burned asbestos. (d) The values of gold are figured at the rate of one crown = $0.203. (e) Potassium and Sodium. (f) Last 10 months only. (g) Metric tons. (h) Not including 188,884 tons of briquettes. (i) Includes bicarbonate.

MINERAL EXPORTS OF AUSTRIA-HUNGARY (a)
(In metric tons or dollars; 5 crowns = $1)

Year.	Alum.	Aluminium Sulphate and Chloride.	Antimony.		Arsenic, Metallic Oxide, Orpiment, and Realgar.	Asbestos.		Asphalt.	
			Ore.	Regulus.		Crude.	Manufactured.	Rock and Earth.	Mastic and Bitumen.
1900	44	164	247	276	65	47	168	1,218	2,177
1901	55	211	179	385	80	36	165	198	1,909
1902	102	135	174	290	89	65	275	520	301
1903	77	14	128	249	63	89	495	921	483
1904	38	2	200	673	72	290	1,582	403	728
1905	68	34	178	774	42	330	1,397	1,060	457
1906 (f)	68	80	314	912	66	376	1,708	2,824	799
1907	75	81	92	698	59	351	630	3,787	771
1908	147	92	161	527	51	442	450	1,312	1,030
1909	65	57	97	185	117	264	561	1,800	758
1910	346	85	54	416	9	262	604	1,545	954
1911	157	16	77	267	13	141	992	1,845	1,218
1912	253	7	54	689	2	530	779	1,357	1,920
1913	454	5	.....	.....	.....	243	1,605	326	2,621

Year.	Barium.		Chloride of Lime.	Cement.	Chrome Ore.	Kaolin and Feldspar.	Coal.		Coke.
	Sulphate (b)	Chloride.					Bituminous.	Lignitic.	
1900	23	.....	192	46,761	22	103,178	815,097	7,864,410	262,793
1901	55	4,098	738	44,723	62	97,037	748,802	8,076,575	303,651
1902	64	4,552	426	39,920	51	100,546	691,680	7,888,218	234,911
1903	52	5,091	674	40,239	100	110,181	754,957	8,027,347	280,395
1904	74	4,233	254	43,110	36	127,984	815,570	7,588,555	353,695
1905	26	4,626	978	52,830	46	137,125	903,156	8,035,718	287,790
1906(f)	2,395	4,503	271	64,883	102	133,326	750,420	7,150,339	246,914
1907	3,119	5,220	308	81,407	161	157,894	849,792	8,876,408	323,243
1908	2,987	2,974	519	65,597	144	154,146	762,867	8,600,683	183,279
1909	2,585	3,737	462	63,463	174	150,878	633,253	8,241,723	198,313
1910	13	4,344	1,213	98,888	140	164,859	615,082	7,492,447	230,735
1911	12	3,741	1,175	168,321	70	174,493	609,737	7,063,981	299,915
1912	2,690	3,658	1,518	149,860	95	187,358	655,106	7,442,392	349,384
1913	753	4,918	2,042	144,596	142	197,693	708,975	7,016,606	369,802

Year.	Fluorspar.	Copper.			Copper Sulphate.	Copperas.	Cryolite.
		Ore.	Crude and Old.	Bars, Sheets, Plates, etc.			
1900	45.0	801	471	200	57	748	237
1901	6.0	1,042	435	334	23	548	231
1902	42.0	1,018	436	381	44	857	363
1903	12.0	1,308	1,226	451	45	898	521
1904	36.0	574	747	577	50	1,170	574
1905	5.0	2,328	1,253	746	49	836	638
1906	*Nil.*	341	1,007	816	99	861	*Nil.*
1907(f)	*Nil.*	489	624	870	11	1,580	*Nil.*
1908	7.0	206	1,126	791	63	2,199	*Nil.*
1909	12.0	136	1,250	541	40	1,877	*Nil.*
1910	4.0	101	977	700	83	2,273	42
1911	0.2	126	1,309	1,109	14	2,124	122
1912	13.0	516	1,332	1,642	119	3,090	46
1913	15.0	182	1,379	1,297	172	2,653	.....

Year.	Gold.			Graphite.	Gypsum.		Hydrochloric Acid.
	Ore.	Bullion. (e)	Specie. (e)		Crude.	Calcined.	
1900	1	$120,988	$11,582,571	18,995	502	1,723	1,659
1901	0	42,427	6,880,888	14,900	461	1,206	1,632
1902	.....	22,939	13,485,087	16,771	550	1,041	791
1903	3	10,150	11,052,944	17,302	342	1,510	3,530
1904	64	5,278	9,649,605	17,430	392	1,510	3,722
1905	1,059	9,338	10,995,089	18,535	363	1,652	4,085
1906	936	88,264	8,015,967	16,871	1,970	686	2,942
1907 (f)	996	1,234,291	13,061,517	21,704	3,841	801	3,708
1908	613	70,005	11,978,828	16,535	7,241	807	3,720
1909	548	3,426,539	19,470,382	18,484	3,675	809	3,263
1910	(h)	1,750,600	10,891,800	21,191	5,110	590	4,856
1911	(h)	6,909,408	15,220,358	21,204	3,689	914	5,834
1912	573	10,952,642	21,008,500	25,246	4,113	1,174	8,461
1913	102	2,092,318	13,719,496	24,492	2,544	988	8,969

Year.	Iron.				Lime.	Magnesium Chloride and Glauber Salts.	Magnesite (Calcined).
	Ore.	Pig and Old.	Manufactures.	Iron and Steel Bars, Sheets, Wire, etc.			
1900	263,421	53,426	40,344	65,019	86,273	7,321	(c)
1901	229,624	26,304	46,508	28,841	82,399	7,960	40,236
1902	241,806	42,592	30,137	45,517	81,634	5,333	53,467
1903	252,520	60,237	40,807	63,031	95,644	2,360	69,058
1904	295,017	66,442	60,252	64,698	101,753	2,151	53,781
1905	373,077	63,780	63,828	69,672	94,751	1,272	92,359
1906(f)	234,924	43,694	73,575	50,247	87,468	4,094	87,765
1907	220,767	37,581	56,472	69,669	89,305	6,905	113,695
1908	220,357	17,494	32,110	29,227	62,938	2,622	87,049
1909	178,464	22,627	25,455	40,837	77,586	5,446	125,668
1910	144,827	96,114	73,473	100,541	391,989	6,332	182,911
1911	114,166	87,975	60,918	75,630	511,996	2,715	147,481
1912	111,436	50,328	48,147	49,907	583,812	2,212	171,196
1913	106,071	21,148	.....	.....	678,194	2,151	200,947

Year.	Lead.						Manganese Ore.	Millstones.	Mineral Paints.	Nickel and Cobalt Ores.
	Ore.	Dross.	Litharge.	Metal and Alloys.	Red and Yellow.	White.				
1900	2,628	66	242	393	34	34	463	1,871	1,906	114
1901	4,143	112	179	68	32	23	398	1,971	1,947	120
1902	5,478	154	124	109	25	37	411	1,886	2,136	34
1903	8,961	147	145	152	19	25	724	2,311	1,873	12
1904	7,575	144	167	464	54	52	1,234	2,276	1,840	24
1905	7,944	342	141	957	60	39	995	2,232	2,091	16
1906(f)	4,891	223	302	602	16	52	4,170	1,763	1,367	6
1907	8,360	420	255	197	9	54	5,273	2,422	1,697	21
1908	7,107	488	312	199	22	50	2,109	3,293	2,292	Nil.
1909	5,711	294	343	306	125	80	787	3,849	2,577	Nil.
1910	6,163	322	160	418	44	510	285	3,970	3,542	13
1911	5,493	154	768	670	24	35	588	3,513	3,426	1
1912	8,618	.....	28	548	19	82	534	3,530	4,272	0
1913	2,828	.....	36	1,060	3	32	550	3,083	3,831	4

Year.	Nitric Acid.	Ozokerite.	Peat and Peat Coke.	Petroleum. (d)	Benzine.	Paraffin.	Potash.	Potassium Chloride.	Pyrite.	Sulphur.
1900....	519	5,162	5,607	33,032	18,361	26	7,792	879	17,162	1,285
1901....	632	2,717	4,558	19,804	17,021	14	4,234	909	16,491	1,225
1902....	769	2,285	4,927	40,683	13,884	24	3,229	772	9,547	1,136
1903....	908	2,258	3,638	74,454	14,000	1,153	3,409	802	10,857	1,123
1904....	858	2,093	3,980	122,419	13,706	5,992	4,604	445	9,891	988
1905....	1,377	1,614	3,746	200,736	8,187	8,996	5,511	1,048	9,168	859
1906(f)	1,303	2,034	2,517	198,325	13,472	9,996	3,814	1,005	7,208	760
1907....	754	1,813	4,001	212,527	12,638	14,758	5,864	1,280	5,646	784
1908....	882	1,648	4,416	351,262	25,599	28,808	4,697	776	6,286	998
1909....	745	2,321	3,395	470,085	32,532	38,043	5,667	793	4,975	1,295
1910....	1,121	2,585	1,963	271,467	39,452	44,432	5,271	957	4,565	658
1911....	1,047	1,859	2,869	220,499	41,923	38,058	4,801	943	1,190	534
1912....	1,251	2,525	1,421	338,271	68,698	51,694	4,456	855	5,041	1,048
1913....	1,373	2,275	1,155	245,184	49,773	43,102	7,460	1,370	3,885	312

Year.	Sulphuric Acid.	Tin.			Whetstones.	Zinc.				
		Ingot and Alloys.	Bars, Plates, Sheets, etc.	Dross.		Ore.	Metallic and Alloys.	Sheets, etc.	White.	Dross.
1900...	12,693	153	102	208	2,270	20,379	1,088	502	1,719	149
1901...	10,373	162	109	257	2,359	23,150	1,374	813	2,720	167
1902...	9,451	193	128	188	2,852	24,519	2,002	1,127	3,113	237
1903...	8,369	292	111	158	2,569	15,108	4,420	729	3,446	267
1904...	9,101	126	102	123	2,159	17,314	4,606	532	3,666	158
1905...	12,823	197	94	78	2,355	19,602	5,023	498	3,861	113
1906(f)	10,493	221	62	83	1,541	15,933	4,578	323	3,504	4,285
1907...	15,190	333	84	160	1,900	19,516	4,608	585	4,873	4,873
1908...	13,581	257	49	172	2,009	19,233	6,604	880	4,131	4,131
1909...	11,232	558	82	59	1,677	19,970	7,031	867	5,078	5,078
1910...	12,016	509	58	70	2,411	22,397	8,720	303	4,968	(g)
1911...	12,111	759	77	59	1,769	16,744	710	411	4,639	(g)
1912...	16,216	(i)1,038	42	.....	1,414	14,539	(i)10,356	2,483	5,890	.....
1913...	14,902	1,061	32	.....	1,358	16,376	13,174	1,383	5,514	.....

(a) From *Statistik des Auswaertigen Handels des Oesterreichisch-Ungarischen Zollgebiets.* (b) Includes artificial barium sulphate. (c) Previous to 1901, magnesite was included with other minerals not elsewhere specified. (d) From 1895 to 1898, inclusive, includes crude and refined petroleum; from 1899 to 1905, inclusive, lubricating oil is also included. (e) Where gold or silver values are reported, 1 crown = $0.203. (f) Last 10 months only. (g) Not reported. (h) Values in gold, $40,200 and $38,760. (i) Includes dross.

BELGIUM

Figures in full-faced type are either provisional figures or estimates.

MINERAL, METALLURGICAL AND QUARRY PRODUCTION OF BELGIUM (a)

(In metric tons except where otherwise noted)

Year.	Barytes.	Chalk-marl. *Cubic Meters.*	Coal.		Coke.	Flint. *Cubic Meters.*	Iron Ore.
			Bituminous.	Briquets.		For Earthenware.	
1900....	38,800	3,228,205	23,462,817	1,395,910	2,434,678	25,700	247,890
1901....	22,800	1,497,250	22,213,410	1,587,800	1,847,730	17,700	218,780
1902....	33,000	1,626,670	22,877,470	1,616,520	2,102,650	17,430	166,480
1903....	21,000	1,580,330	23,796,680	1,686,415	2,428,020	16,250	184,400
1904....	60,000	1,645,655	(c)22,761,430	1,735,480	2,496,340	18,070	206,730
1905....	26,000	1,493,745	21,775,280	1,711,920	2,526,690	12,800	176,620
1906....	22,365	1,521,660	23,569,860	1,887,090	2,712,760	14,900	232,570
1907....	23,000	1,537,210	23,705,190	2,040,670	2,771,920	15,050	316,250
1908....	25,070	1,441,005	23,557,900	2,421,210	2,632,890	15,430	188,780
1909....	31,400	1,445,015	23,517,550	2,707,390	2,972,920	15,280	199,710
1910....	4,900	1,546,750	23,916,560	2,651,190	3,110,820	16,400	122,960
1911....	25,200	1,667,125	23,053,540	2,778,620	3,160,950	10,950	150,500
1912....	32,400	1,745,070	22,972,140	2,690,510	3,175,500	5,930	167,370
1913....	12,000	1,687,085	**22,845,310**	**2,608,640**	**3,447,310**	16,690	150,450

Year.	Iron, Crude.					Iron and Steel.			
	Foundry Pig.	Forge Pig.	Bessemer Pig.	Basic Pig.	Total Pig.	Ingots of Steel.	Merchant Bars.	Beams & Special Bars.	Tires.
1900....	88,335	305,344	176,557	447,271	1,018,561	655,199	.....	.....	11,934
1901....	86,170	178,250	166,820	332,940	764,180	515,780	334,910	186,200	12,380
1902....	104,540	254,710	199,170	510,630	1,069,050	769,040	380,990	223,380	12,790
1903....	91,600	256,890	229,160	638,430	1,216,080	969,230	446,360	138,270	17,810
1904....	99,350	224,410	217,390	742,040	1,287,597	1,065,870	543,260	268,360	23,540
1905....	98,170	206,390	220,210	784,850	1,311,120	1,200,430	570,130	299,840	25,810
1906....	96,090	218,225	177,900	870,860	1,375,775	1,440,880	552,850	346,420	32,070
1907....	92,280	189,190	88,650	1,008,170	1,406,980	1,521,610	594,170	327,930	34,700
1908....	76,290	116,740	78,950	996,870	1,270,050	1,249,620	544,810	241,060	29,000
1909....	91,040	127,080	56,430	1,340,060	1,616,370	1,580,350	628,740	291,260	33,960
1910....	82,410	115,760	55,650	1,596,970	1,852,090	1,892,160	672,730	340,850	31,860
1911....	52,970	102,690	46,240	1,836,720	2,046,280	2,128,170	711,220	380,160	35,450
1912....	94,810	66,940	44,250	2,093,480	2,301,290	2,442,420	609,930	390,340	40,320
1913....	93,830	66,370	32,260	2,291,390	2,484,690	3,104,780	855,547	213,940	175,210

Year.	Iron and Steel.				Lead.		Manganese Ore.
	Rails.	Plates.	Sheets.	Total Wrought and Steel.	Ore.	Pig.(a)	
1900	134,428	.....	.....	926,752	230	16,365	10,820
1901	132,260	95,190	55,300	870,230	220	61,900	8,510
1902	(c)268,220	101,280	67,350	1,106,950	164	73,357	14,440
1903	(c)351,540	113,830	74,080	1,376,630	90	68,700	6,100
1904	(c)266,900	126,960	79,040	1,378,750	91	(f)23,470	485
1905	241,640	167,240	76,510	1,469,020	126	22,885	*Nil.*
1906	274,920	166,970	84,150	1,522,995	121	23,765	120
1907	314,760	148,690	82,420	1,575,110	210	27,450	2,100
1908	(c)191,370	135,390	93,790	1,296,050	195	35,650	7,130
1909	214,000	170,750	112,160	1,569,560	150	40,306	6,270
1910	347,890	177,110	122,830	1,834,050	162	40,715	*Nil.*
1911	337,520	211,410	130,250	1,945,220	82	44,308	*Nil.*
1912	339,060	251,380	119,390	1,903,270	107	54,940	*Nil.*
1913	341,870	241,200	137,570	2,224,057	**132**	**35,750**	*Nil.*

Year.	Mineral Paints.	Phosphate of Lime.	Pyrite.	Slate. *Pieces.*	Silver. *Kg.*	Zinc.			
	Ochers.					Ore (Blende)	Ore (Calamine).	Spelter.	Sheets.
1899	(b) 300	(b)190,090	283	44,167,000	134,854	5,736	3,730	122,843	34,289
1900	(b) 300	(b)215,670	400	43,941,000	146,548	5,715	3,000	119,317	38,825
1901	2,100	222,520	560	39,030,000	169,450	4,445	2,200	127,170	37,380
1902	200	135,850	760	37,120,000	212,922	3,568	284	124,780	37,070
1903	200	184,120	720	38,953,000	232,740	3,565	65	131,740	42,280
1904	450	202,480	1,075	41,240,000	252,920	3,698	4	137,323	41,490
1905	300	193,305	976	41,435,000	201,935	3,929	*Nil.*	142,555	45,320
1906	250	152,140	908	43,801,000	173,535	3,858	*Nil.*	148,035	44,525
1907	200	181,230	397	40,102,000	178,020	3,485	5	152,370	45,330
1908	.....	198,030	357	41,180,000	228,000	2,099	3	161,940	43,410
1909	700	205,260	214	41,630,000	271,270	1,229	*Nil.*	174,490	44,850
1910	600	202,880	214	36,440,000	264,655	1,434	*Nil.*	181,745	47,970
1911	540	196,780	122	37,620,000	252,720	836	*Nil.*	198,230	48,450
1912	650	203,110	148	29,600,000	279,960	1,167	*Nil.*	205,940	49,120
1913	600	219,420	**268**	27,390,000	253,940	**1,100**	*Nil.*	204,225	51,490

(a) From *Statistique des Industries Extractives et Metallurgiques et des Appareils à vapeur en Belgique.* (b) Cubic meters. (c) Includes beams. (e) Net production from this year on. (f) Domestic lead only, beginning with this year.

CANADA

The statistics of mineral production in the Dominion of Canada as reported by the Geological Survey are summarized in the following tables. The statement of imports and exports for 1907 is for the nine months ending March 31, in consequence of a change in the law whereby the fiscal year was changed from June 30:

MINERAL PRODUCTION OF THE DOMINION OF CANADA (a)
(In metric tons or dollars)

Year.	Arsenic.	Asbestos and Asbestic.	Barytes.	Cement. *Barrels.* (f)		Chromite.	Coal.	Cobalt.	Coke. (k)
				Natural Rock.	Portland.				
1901....	630	36,477	592	133,328	317,066	1,274	5,648,208	.....	331,537
1902....	726	36,657	994	127,931	594,594	900	6,524,180	.....	455,353
1903....	725	37,902	1,055	92,252	627,741	3,509	6,933,107	.....	509,115
1904....	(d) 66	44,131	1,253	51,555	771,650	5,511	6,812,834	.....	493,107
1905....	*Nil.*	61,928	3,049	14,184	1,346,547	7,781	7,961,397	.....	622,154
1906....	*Nil.*	72,025	3,628	8,610	2,139,164	7,936	9,033,973	.....	(b)
1907....	317	82,117	1,829	5,775	2,368,593	6,527	9,533,442	.....	(b)
1908....	634	82,448	3,911	1,044	2,665,289	7,341	9,857,754	841	784,788
1909....	1,024	79,197	(b)	(b)	4,067,709	2,240	9,526,938	(i)	782,016
1910....	1,362	92,800	(b)	(b)	4,753,975	276	11,711,000	(i)	818,450
1911....	1,902	115,136	45	(b)	5,692,915	143	10,243,528	(i)	848,280
1912....	1,855	123,679	421	(b)	7,132,732	(b)	13,168,941	(i)	1,275,829
1913....	1,535	146,169	581	(b)	8,658,805	(b)	13,622,070	(i)	1,376,646
1914....	1,576	106,686	555	(b)	7,172,480	123	12,336,088	.....	921,241

Year.	Copper. (In Ore, etc.)	Corundum.	Feldspar.	Gold. (c)	Graphite.	Grindstones.	Gypsum.	Iron Ore.	Iron, Pig. All kinds.
1901..	17,155	403	4,852	$24,128,503	2,004	4,155	266,476	284,477	248,839
1902..	17,598	697	6,871	21,336,667	993	5,835	301,165	366,431	324,617
1903..	19,357	880	12,633	18,843,590	660	5,023	285,242	239,715	270,182
1904..	19,497	834	10,057	16,400,000	410	4,091	309,133	317,387	275,367
1905..	21,596	1,492	10,617	14,486,833	491	4,693	395,341	263,113	475,491
1906..	25,863	2,063	14,397	12,023,932	405	5,029	378,904	269,842	550,628
1907..	26,025	1,716	11,414	8,264,765	525	4,881	431,286	283,820	590,444
1908..	28,895	988	7,144	9,842,105	227	3,285	309,254	215,986	572,284
1909..	23,811	1,353	11,594	9,382,230	783	3,877	429,218	(d) 243,167	(g) 686,886
1910..	25,262	1,696	14,114	10,205,835	1,263	3,604	476,496	(d) 235,342	(g) 726,471
1911..	25,250	1,336	16,074	9,781,077	1,151	4,818	458,550	190,823	(g) 832,376
1912..	35,314	1,778	12,461	12,648,794	1,869	4,003	524,892	107,190	(g) 920,636
1913..	34,926	1,068	15,235	16,598,923	1,962	4,389	577,442	196,558	(g) 1,024,424
1914..	34,364	507	16,388	15,925,044	1,494	3,700	463,375	54,816	(g) 783,164

Year.	Iron and Steel, Rolled.	Lead. (In ore, etc.)	Manganese Ore.	Mica.	Mineral Paints. (Ochers)	Natural Gas.	Nickel. (In ore, etc.)	Petroleum, Crude. *Barrels.* (e)
1901....	113,799	23,537	(d)399	$160,000	2,025	$339,476	4,167	623,392
1902....	164,069	10,411	(d)156	135,904	4,494	195,992	4,849	530,624
1903....	131,588	8,226	83	177,857	5,683	202,210	5,671	486,637
1904....	(b)	17,241	(d)112	152,919	3,562	247,370	4,786	552,575
1905....	(b)	25,391	(d) 20	168,170	4,632	314,249	8,565	634,095
1906....	(b)	24,580	(d) 84	(d)581,043	6,201	528,868	9,745	569,753
1907....	(b)	21,570	.....	333,022	7,115	748,541	9,610	788,872
1908....	(h)534,117	19,593	.....	139,871	4,305	1,012,660	8,685	527,987
1909....	(h)684,670	20,801	.....	147,782	3,573	1,207,029	11,922	420,755
1910....	(h)745,963	14,963	.....	190,385	4,365	1,346,471	16,905	315,895
1911....	(h)800,722	10,617	5	128,667	3,285	1,917,673	15,457	291,092
1912....	868,617	16,227	68	143,976	6,945	2,362,700	20,346	243,336
1913....	.....	17,089	0	194,304	5,432	3,309,381	22,539	228,089
1914....	.....	16,487	25	102,315	5,345	3,511,302	20,652	214,805

Year.	Phosphate. (Apatite.)	Pyrite.	Salt.	Silver. *Kg.* (In ore, etc.)	Soapstone and Talc.
1	937	31,982	53,901	172,292	235
2	776	32,304	58,462	133,478	625
3	1,205	30,822	56,644	99,489	898
4	832	29,980	62,411	115,666	762
5	1,180	29,713	41,159	185,839	454
6	(*b*)	35,927	69,283	266,521	1,119
7	680	35,494	65,936	390,359	1,391
8	1,447	42,934	72,537	687,504	976
9	905	58,645	76,237	856,263	3,945
0	1,341	48,871	76,286	1,022,350	6,450
1	563	74,978	83,065	1,012,586	6,621
2	149	73,976	86,248	993,952	7,504
3	349	143,882	91,457	990,538	11,115
4	866	204,125	97,126	856,741	9,807

(*a*) From *Reports Compiled by the Geological Survey of Canada.* (*b*) Not reported. (*c*) Gold ies are calculated at the rate of $20.67 per oz. (*d*) Export. (*e*) One barrel contains 35 imp. gal. From Canadian ore, 149,444 short tons in 1909, 104,906 tons in 1910, 42,186 tons in 1911, 355 tons in 1912, 73,508 tons in 1913 and 95,744 in 1914. (*h*) Steel ingots and castings. (*i*) 1909, ,609; 1910, $51,986; 1911, $221,790; $320,244 in 1912, $695,855 in 1913 $678,619 in 1914, for ies of cobalt and nickel; values received. (*j*) Bbl. of 350 lb. each, sold or shipped. (*k*) Including t from foreign coal.

MINERAL IMPORTS OF THE DOMINION OF CANADA (*a*)

(In metric tons or dollars)

Year. (*b*)	Aluminium.		Antimony. (*c*)	Arsenic.	Asbestos. (*d*)	Asphalt.	Cement.
	Manufactures. (*m*)	Ingots, Sheets, etc.					
2	$30,496	.....	229	48	$52,464	3,426	$863,646
3	14,201	$13,930	393	135	75,465	3,037	890,745
4	16,065	101,427	190	188	83,827	7,093	1,014,713
5	28,418	154,569	85	122	116,836	5,096	1,263,828
6	23,565	168,405	183	202	138,000	7,178	1,003,022
7(*e*)	20,656	218,399	146	158	127,509	11,929	540,006
8(*r*)	37,197	131,762	220	228	191,204	14,113	865,275
9(*r*)	30,076	167,019	201	58	181,710	15,979	473,211
0(*r*)	42,493	424,006	232	12	198,756	19,661	159,040
1(*r*)	83,638	782,254	257	115	254,331	23,248	(*i*)494,446
2(*r*)	119,070	487,490	233	159	349,655	28,291	(*i*)936,425
3(*r*)	126,531	403,700	400	259	497,160	47,353	(*i*)1,955,177
4(*r*)	151,261	730,012	322	127	474,499	48,564	(*i*)352,134
5(*r*)	87,242	[672,527	733	8	226,515	38,175	(*i*)132,492

Year.	Coal.		Coke.	Copper.	Copper Sulphate.	Gold and Silver.
	Anthracite. (*f*)	Bituminous. (*f*)		Ingots, Pig, and Scrap.		Coin and Bullion. (*g*)
2	1,498,773	3,208,005	242,298	801	711	$6,311,405
3	1,320,239	3,684,502	232,848	924	1,010	8,976,797
4	2,064,444	4,230,436	200,590	960	795	7,874,313
5	2,361,952	4,377,667	337,035	882	934	10,308,435
6	1,996,183	5,003,029	435,561	1,191	844	7,078,603
7(*e*)	1,260,723	4,022,843	363,286	1,186	897	7,029,047
8(*r*)	2,803,681	7,681,464	561,677	1,638	1,161	6,548,661
9(*r*)	2,775,680	6,526,797	423,013	1,239	963	9,988,442
0(*r*)	2,860,196	10,382,156	636,888	2,329	859	6,017,589
1(*r*)	3,144,130	7,785,259	692,292	2,279	772	10,206,210
2(*r*)	3,736,169	9,526,138	582,331	2,514	930	26,033,881
3(*r*)	3,844,062	10,034,383	644,207	2,581	1,153	5,527,979
4(*r*)	3,979,674	12,479,959	643,693	2,511	606	15,235,317
5(*r*)	3,971,968	8,279,570	460,381	2,053	335	131,993,031

Year.	Graphite.		Gypsum.		Iron and Steel.		
	Crude.	Manufactures. (h)	Crude and Ground.	Plaster of Paris.	Pig and Scrap.	Slabs, Blooms Bars, etc.	Alloys of Iron.
1903.....	$2,870	$69,676	1,007	286	129,641	17,896	5,762
1904.....	1,802	67,563	626	291	86,087	9,088	2,700
1905.....	2,499	75,288	2,972	3,595	90,698	14,420	11,738
1906.....	2,791	86,028	5,743	6,579	112,937	29,520	13,626
1907(o).....	3,176	57,430	8,334	9,730	137,654	17,369	17,785
1908(r).....	3,030	78,380	8,519	6,955	190,994	35,534	16,139
1909(r).....	1,408	75,608	9,359	7,712	62,967	43,263	13,571
1910(r).....	5,223	95,900	3,618	19,095	159,515	97,036	14,471
1911(r).....	4,300	97,057	11,443	19,664	266,269	139,060	15,773
1912(r).....	6,163	84,240	2,130	9,313	214,046	80,250	16,578
1913(r).....	6,105	89,719	8,800	28,975	306,927	77,176	20,837
1914(r).....	3,639	71,340	4,877	15,084	251,730	145,731	26,256
1915(r).....	1,464	43,313	3 236	5,769	69,261	50,086	2,534

Year.	Kainite.	Lead.				Lime.		Mineral Paints (Ochers).
		Pig and Scrap.	Bars and Sheets.	Litharge.	Pigments and Zinc White.	Burned. *Barrels.*	Chloride.	
1903...	259	(i)4,471	523	632	8,715	31,108	2,104	1,459
1904...	339	4,292	.....	.....	7,679	54,359	2,080	1,256
1905...	306	2,589	800	811	9,695	98,676	2,507	1,417
1906...	306	3,751	730	461	6,947	134,334	2,645	809
1907(o)	511	3,811	622	513	2,215	88,919	2,302	570
1908(r)	743	2,902	782	864	5,743	129,379	3,421	788
1909(r)	562	2,273	623	550	3,998	153,934	2,697	546
1910(r)	687	5,755	580	915	4,433	191,527	4,554	914
1911(r)	339	5,292	707	750	5,312	176,730	4,745	1,169
1912(r)	262	10,934	1,356	745	4,921	230,013	5,584	1,358
1913(r)	19	10,980	918	1,197	6,627	360,242	5,248	1,649
1914(r)	180	5,078	654	512	7,547	.....	6,264	1,605
1915(r)	350	7,539	358	479	5,350	.....	2,446	1,282

Year.	Nickel.	Petroleum Products.		Platinum.	Potassium Salts.		Quicksilver.
		Illuminating Oil, etc., Crude or Refined. *Gallons.*	Paraffin Wax and Candles.		Except Saltpeter.	Saltpeter.	
1903.....	$26,177	18,799,312	307	$21,251	1,060	916	75
1904.....	14,682	24,521,115	228	28,112	1,151	898	69
1905.....	19,076	13,229,855	98	61,719	945	1,048	47
1906.....	15,976	10,981,611	375	54,494	1,317	1,141	68
1907(o).....	19,461	8,066,403	189	113,967	1,074	638	44
1908(r).....	.....	8,844,129	102	63,582	3,396	2,653	81
1909(r).....	(s)67,107	13,095,593	103	47,371	1,570	925	42
1910(r).....	(s)98,238	(u)48,384,763	253	80,180	2,497	665	129
1911(r).....	137,114	(u)66,119,105	931	136,823	3,152	1,490	59
1912(r).....	135,227	88,916,283	808	190,770	3,734	1,049	49
1913(r).....	194,079	164,013,894	892	221,300	5,643	835	67
1914(r).....	144,343	202,540,731	717	121,336	8,057	776	115
1915(r).....	172,037	211,900,141	623	65,008	4,139	1,034	67

Year.	Sal-Ammoniac.	Salt.	Silex.	Sodium Salts, Except Chloride.	Sulphur.	Tin and Tin-ware.	Zinc.
1903	114	112,188	159	18,887	11,077	$2,712,168	1,209
1904	93	103,635	252	25,118	8,786	2,389,557	1,540
1905	143	97,723	405	26,219	10,633	2,791,757	1,721
1906	209	99,788	338	30,401	19,512	3,105,876	3,383
1907(o)	130	73,156	542	25,068	11,725	2,473,572	2,761
1908(r)	172	105,286	1,131	39,154	23,494	1,619,647	2,521
1909(r)	162	119,660	417	33,787	19,981	2,984,065	2,993
1910(r)	303	121,473	582	47,913	19,484	3,512,615	(v)7,606
1911(r)	346	111,174	468	62,969	22,935	4,235,848	(v)6,069
1912(r)	377	119,114	337	74,016	20,430	3,710,102	7,217
1913(r)	544	100,494	658	98,561	32,984	3,055,943	9,397
1914(r)	356	132,777	755	100,701	27,093	6,350,610	7,402
1915(r)	430	121,683	582	78,894	39,412	4,783,108	7,230

EXPORTS OF DOMESTIC MINERAL PRODUCE FROM THE DOMINION OF CANADA (a)
(In metric tons or dollars)

Year. (b)	Antimony Ore.	Asbestos.	Chromite.	Coal.	Coke.	Copper. (c)
1903	128	27,823	658	1,796,689	39,616	13,445
1904	87	31,444	2,103	1,494,106	61,750	20,279
1905	340	37,320	3,702	1,465,809	116,387	17,431
1906	388	40,367	1,640	1,651,203	50,004	20,082
1907(o)	832	37,194	604	1,165,809	44,669	11,845
1908(r)	693	53,543	1,585	1,702,673	50,343	25,824
1909(r)	1	54,188	3,707	1,548,468	70,024	24,642
1910(r)	33	58,083	1,052	1,822,398	44,343	26,107
1911(r)	222	63,348	14	2,100,309	54,380	24,950
1912(r)	1	69,233	.....	1,436,798	13,677	25,595
1913(r)	.....	83,299	.....	1,920,809	56,271	36,717
1914(r)	.....	96,159	.....	1,360,029	66,512	37,772
1915(r)	306	67,968	72	1,372,431	47,978	28,438

Year.	Gold. Quartz, Dust, etc.	Graphite.	Grindstones.	Gypsum, Crude.	Iron Ore.	Lead. (p)
1903	$16,437,528	530	$14,169	271,899	(n)267,000	7,386
1904	18,715,539	269	12,676	247,741	(n)214,309	7,329
1905	15,208,380	201	27,985	290,574	204,091	23,094
1906	12,991,916	180	15,793	367,203	134,270	6,158
1907(o)	7,226,954	3	33,929	249,780	31,011	8,330
1908(r)	8,817,041	167	28,726	340,235	23,863	12,650
1909(r)	7,392,610	396	18,019	239,139	3,568	5,459
1910(r)	6,110,473	1,164	13,754	304,736	28,608	8,395
1911(r)	5,344,465	362	23,914	325,928	95,080	1,451
1912(r)	7,211,438	1,395	30,513	324,324	34,162	52
1913(r)	11,231,476	1,572	27,375	344,183	123,004	93
1914(r)	13,326,755	1,367	54,584	359,287	103,126	125
1915(r)	15,406,510	451	45,889	292,800	198,412	328

Year.	Manganese Ore.	Mica.	Nickel in Ore, Matte, etc.	Petroleum, Crude and Refined.	Pyrites.	Salt. *Bushels.*	Silver (in Ore, Matte, etc). *Kg.*
1903	137	632	4,098	413	16,762	7,959	100,861
1904	62	393	6,456	1,208	15,582	42,662	99,472
1905	84	461	5,431	6,441	20,473	5,663	112,076
1906	15	603	10,866	1,741	18,398	23,168	203,323
1907(o)...	84	631	7,355	(q)3,167	20,148	5,113	274,178
1908(r)...	1	409	8,596	(q)3,389	17,835	35,543	515,161
1909(r)...	3	243	8,895	(q)195	23,087	(w)3,040	733,248
1910(r)...	5	397	13,891	(q)9,093	24,439	(w)6,088	932,098
1911(r)...	2	370	15,771	(q)1,493	32,396	(w)6,625	1,049,153
1912(r)...	12	348	15,073	38,663	25,279	109,963	960,586
1913(r)..	7	415	21,849	152,746	3,109	60,536	1,096,835
1914(r)...	.....	321	22,949	(q)25,443	42,006	(w)6,165	1,143,337
1915(r)...	82	387	20,604	(q)18,376	87,021	(w)15,865	788,656

(a) From Tables of the *Trade and Navigation of the Dominion of Canada.* (b) Fiscal year ending June 30. (c) Includes regulus and salts of antimony. (d) Asbestos in any form except crude, and all manufactures of. (e) Includes copper in ore, matte, regulus, etc. (f) Includes coal dust. (g) Coin, gold and silver, except U. S. silver coin. (h) Includes black lead and crucibles (clay or graphite). (i) Includes Canadian lead ore refined in the United States. (m) Unclassified. (n) Includes chromic iron ore. (o) Returns for the 9 months of the fiscal year ending March 31. (p) Includes lead contained in ore, etc. (q) Gallons. (r) Fiscal year ending March 31. (s) Includes silver-nickel and German silver. (t) Weight, 64,176 tons; 46,821, 247,940, 35,431, and 14,370 net tons. (u) Includes all oils. (v) Not including manufactures. (w) Using 60 lb. per bushel.

CHINA

The official statistics of mineral imports and exports are summarized in the following table:

MINERAL IMPORTS OF CHINA (*a*)

(In metric tons)

Year.	Brass and Yellow Alloys.	Copper.	Lead.	Nickel.	Petroleum. *Gal.*	Quicksilver.	Tin.	Tinplate.	Zinc.	
									Spelter.	Sheet, etc.
1910...	1,674	2,428	9,247	134	161,399,583	51	2,684	11,569	.....	858
1911...	1,244	4,408	8,138	39	235,898,240	49	1,994	21,676	81	769
1912...	970	7,368	6,187	56	197,902,362	49	2,548	21,036	443	861
1913...	.....	12,144	6,511	.....	183,984,052	.....	3,193	21,983	.....	.....
1914...	.....	.....	.....	.....	225,464,201	.....	.....	.....	.....	.....

MINERAL EXPORTS OF CHINA (*a*)

(In metric tons)

Year.	Antimony.		Iron.		Lead.		Quicksilver.	Tin.	Zinc.	
	Ore.	Metal.(*b*)	Ore.	Pig and Mnfd.	Ore.	Pig.			Ore.	Spelter.
1910.....	5,762	6,643	132,561	65,381	5,176	3	48.5	6,510	9,786	328
1911.....	6,812	6,986	112,295	70,906	5,410	11	18.5	6,056	4,599	710
1912.....	2,054	13,531	355,538	12,604	4,276	20	4.3	8,786	7,170	760
1913.....	4,351	13,032	274,064	64,811	4,066	42	2.1	8,390	9,550	908
1914.....	4,972	19,645	299,515	60,068	3,722	235	59.7	7,215	7,374	310

(*a*) From annual reports of the Imperial Chinese Maritime Customs. (*b*) Regulus and refined.

FRANCE

In the following tables are given the statistics of mineral and metal production in France and the French colonies—Algeria, New Caledonia and Tunis—together with the foreign commerce of France in mineral and metal products. Figures in full-faced type are either provisional figures or estimates.

MINERAL AND METALLURGICAL PRODUCTION OF FRANCE (a)
(In metric tons)

Year.	Aluminium.	Antimony.		Arsenic Ore.	Asphaltum.	Barytes.	Bauxite.	Bitumen. (c)	Cement.
		Ore.	Metal.						
1901.....	1,200	9,867	1,786	7,491	20,391	4,145	76,620	249,655	1,127,206
1902.....	1,355	9,715	1,725	5,372	.....	4,323	96,900	258,295	962,930
1903.....	1,570	12,380	2,748	6,658	.....	5,731	133,890	243,295	898,393
1904.....	1,650	9,065	2,116	3,117	22,000	6,944	75,640	227,177	903,632
1905.....	1,905	12,543	2,396	3,627	20,000	5,504	103,207	188,403	922,531
1906.....	3,396	18,567	3,433	6,534	38,231	11,680	117,781	196,375	1,257,861
1907.....	4,700	24,000	3,950	7,900	33,000	11,150	158,000	177,000	1,253,546
1908.....	4,681	26,026	3,850	2,381	41,000	16,277	170,679	171,158	1,359,658
1909.....	6,092	28,105	5,444	2,141	44,800	14,111	130,149	169,000	1,374,574
1910.....	6,425	28,130	4,640	8,045	38,500	11,632	196,056	169,769	1,521,131
1911.....	7,400	29,267	4,775	19,000	39,000	10,064	254,831	170,000	1,795,000
1912.....	10,200	11,018	(f)5,406	81,880	31,535	13,620	258,929	312,000	1,924,277
1913.....	13,483	17,036	6,390	70,613	30,892	12,236	309,294	324,601	1,930,066

Year.	Coal.	Lignite.	Peat.	Copper.		Gold.	Gypsum.	
				Ore.	Metal.		Crude.	Calcined.
1902.....	29,365,047	632,423	109,941	828	6,300	(b)	219,487	1,572,687
1903.....	34,217,661	688,757	100,348	10,892	6,921	(b)	162,766	1,468,830
1904.....	33,502,394	665,572	95,716	2,756	6,900	(b)	106,173	1,481,303
1905.....	35,218,000	709,000	98,500	5,068	7,576	$235,447	78,832	1,299,313
1906.....	33,458,000	738,000	92,469	2,547	5,770	511,665	79,568	1,297,861
1907.....	35,989,000	765,000	90,952	2,400	7,800	847,290	87,370	1,316,567
1908.....	36,633,000	751,000	79,759	766	7,935	960,666	92,898	1,326,131
1909.....	37,115,500	724,500	78,600	458	7,823	1,147,400	76,057	1,263,692
1910.....	37,634,893	715,000	48,415	222	12,933	(h) 1,706,580	64,181	1,533,298
1911.....	38,521,000	709,000	58,521	35	13,200	(h) 1,463,519	59,648	1,640,698
1912.....	41,145,000	751,000	43,000	242	11,907	1,993,620	25,900	1,700,000
1913.....	40,050,888	793,330	44,878	521	11,968	153,009	66,218	.....

Year.	Iron.				Lead.		Lime.	Manganese Ore.	Millstones.
	Ore.	Pig.	Wrought Iron.	Wrought Steel.	Ore. (d)	Pig. (e)			
1902.	5,003,782	2,405,000	639,600	1,245,800	22,634	19,000	4,796,807	12,536	34,504
1903.	6,219,541	2,840,517	598,910	1,305,709	23,080	23,258	4,727,543	11,583	35,031
1904.	7,022,841	2,999,787	554,632	1,482,708	14,173	18,800	4,583,522	11,254	37,409
1905.	7,395,409	3,077,000	670,000	1,442,000	12,118	24,100	3,694,725	6,751	33,468
1906.	8,481,423	3,314,100	747,900	1,683,500	11,795	25,614	3,869,772	11,189	32,407
1907.	10,008,000	3,590,000	579,900	1,860,000	18,000	24,800	2,438,409	18,200	30,480
1908.	10,057,145	3,400,700	560,200	1,851,900	13,403	26,112	2,535,833	15,865	30,522
1909.	11,890,000	3,573,848	558,000	2,040,364	13,794	26,927	2,211,653	9,378	30,503
1910.	14,605,542	4,038,000	526,000	2,324,000	14,536	20,226	2,110,540	7,925	32,461
1911.	16,639,000	4,470,100	518,000	3,812,665	14,098	23,635	3,291,000	6,036	34,255
1912.	19,160,000	4,939,194	525,000	4,403,688	13,953	31,086	3,807,596	5,576	33,751
1913.	21,918,000	5,207,307	405,972	4,686,866	17,081	28,817	2,838,392	7,732	29,994

Year.	Mineral Paints. (Ochers)	Nickel.	Phosphate Rock.	Pyrite.	Salt.	Silver. *Kg.*	Sulphur Ore. (*g*)	Zinc.	
								Ore.	Metal.
1901....	35,704	1,800	535,676	307,447	910,000	.....	7,000	61,539	37,600
1902....	34,770	1,600	543,900	318,235	863,927	.....	8,021	57,982	36,300
1903....	34,042	1,500	475,783	322,118	967,531	.....	7,375	66,922	37,416
1904....	34,945	1,500	423,521	271,544	1,153,754	.....	5,447	52,842	41,600
1905....	37,800	1,800	476,720	267,114	1,162,100	.....	4,637	62,150	43,200
1906....	35,550	1,750	469,408	265,261	1,388,500	50,058	2,713	53,466	46,536
1907....	32,856	1,500	432,237	283,000	1,324,000	47,009	2,000	44,000	47,900
1908....	33,060	1,800	485,607	284,717	1,173,000	61,184	2,189	52,611	47,880
1909....	33,540	1,600	397,908	273,221	1,113,000	63,671	2,900	96,903	49,956
1910....	32,870	2,100	333,506	250,432	1,051,427	52,957	2,641	50,624	52,598
1911....	34,542	1,180	312,204	277,900	1,339,000	47,277	1,200	43,761	57,110
1912....	41,810	1,725	313,151	282,202	1,099,000	63,736	1,000	45,929	62,651
1913....	56,240	1,500	298,859	311,167	1,281,978	31,268	659	46,577	67,890

(*a*) From *Statistique de l'Industrie Minérale.* (*b*) Not reported. (*c*) Includes pure bitumen, bituminous schist and sand, and asphaltic limestone. (*d*) Argentiferous lead ore. (*e*) Lead produced from native ores only. (*g*) Sulphur and limestone impregnated with sulphur. (*h*) From ores. (*i*) Regulus and oxide.

MINERAL PRODUCTION OF ALGERIA (*a*)

(In metric tons)

Year.	Antimony Ore.	Copper Ore.	Gypsum.		Iron Ore.	Lead-Silver Ore.	Mercury.	Onyx.	Phosphate Rock.	Salt.	Zinc Ore.
			Crude.	Plaster.							
1901...	....	7,267	600	34,740	161,303	1,614	.....	294	265,000	18,518	26,913
1902...	39	1,955	600	35,500	525,012	26	.....	150	305,174	27,263	33,139
1903...	490	100	300	33,000	588,893	499	.....	67	320,834	26,329	43,313
1904...	160	1,804	350	38,420	468,737	511	.....	121	343,317	18,563	47,192
1905...	.....	1,784	.....	34,743	568,609	7,470	.....	270	334,784	26,986	67,922
1906...	50	2,786	.....	27,950	779,826	11,246	.....	216	333,531	22,615	74,351
1907...	799	16,259	.....	26,400	973,445	15,264	590	328	373,763	20,390	71,046
1908...	190	3,330	.....	25,500	943,424	10,626	1,556	300	452,060	25,215	94,398
1909...	163	67	.....	29,000	836,044	11,131	.....	200	345,385	17,817	81,852
1910 (*a*)	(*c*)4475	112	.....	48,500	1,064,909	12,652	50	123	412,319	21,470	94,445
1911...	(*c*)7428	4,939	.....	51,760	1,025,643	17,909	.....	198	335,059	20,431	60,895
1912...	(*c*)2165	316	.....	54,400	1,225,625	24,516	.....	300	373,881	23,950	84,495
1913...	(*c*)582	13,164	700	50,399	1,349,000	13,953	18	168	377,934	26,969	82,256

MINERAL PRODUCTION OF NEW CALEDONIA. (*a*)

(In metric tons.)

Year.	Chrome Iron Ore.	Cobalt. Ore.	Copper Ore.	Nickel. Ore.	Year.	Chrome Iron Ore.	Cobalt Ore.	Copper Ore.	Nickel Ore.
1900.....	10,474	2,438	2	100,319	1907...	57,367	29,800	437	119,000
1901.....	17,451	3,123	6,349	132,814	1908...	25,371	2,360	(*b*) 10	108,000
1902.....	10,281	7,512	3,720	129,653	1909...	40,000	548	9,600	86,000
1903.....	21,437	8,292	10	77,360	1910...	40,000	54	8,000	99,000
1904.....	42,197	8,964	*Nil.*	98,655	1911...	35,000	*Nil.*	1,900	142,000
1905.....	51,374	7,920	*Nil.*	125,289	1912(*c*)	51,516	*Nil.*	(*d*)	74,312
1906	84,211	2,600	207	118,890	1913(*c*)	63,370	.....	.....	164,406

(*a*) From *Statistique de l'Industrie Minérale.* (*c*) Exports *Echo des Mines.* (*d*) Copper matte worth $101,000.

MINERAL PRODUCTION OF TUNIS (a)

(In metric tons)

Year.	Salt.	Lead Ore.	Phosphate of Lime.	Zinc Ore.	Year.	Salt.	Lead Ore.	Phosphate of Lime.	Zinc Ore.
1901....	16,900	8,158	172,000	17,879	1908...	149,600	37,500	1,300,500	26,500
1902....	12,600	12,892	264,930	18,400	1909...	118,400	41,600	1,300,000	24,500
1903....	18,846	12,752	352,088	21,262	1910...	199,700	(c) 37,000	1,234,000	(c) 32,500
1904....	23,600	16,800	455,197	27,200	1911...	63,700	36,100	1,592,000	(c) 27,900
1905....	54,900	15,200	522,000	37,100	1912...	92,000	51,300	2,050,000	37,400
1906....	62,600	14,800	796,000	32,400	1913(b)	94,100	52,200	2,170,500	30,300
1907....	78,200	18,600	1,069,000	22,800					

(a) From *Statistique de l'Industrie Minérale.* (b) From *l'Echo des Mines.*

MINERAL IMPORTS OF FRANCE (a) (k)

(In metric tons or dollars. 5 f. = $1)

Year.	Alum.	Bitumen. (f)	Borax.	Bromides.	Cement.	Coal and Coke.	Copper.		Copper.	
							Ore.	Ingot and Mfrs.	Sulphate.	Oxide.
1898....	27	20,385	139	30	11,290	10,445,090	8,779	52,976	30,897	52
1899....	34	30,770	123	46	13,640	11,896,030	8,517	58,419	21,733	36
1900....	23	39,598	111	10	13,612	14,601,981	9,766	61,638	22,820	84
1901....	39	28,888	128	3	16,232	13,925,623	13,383	47,035	15,313	162
1902....	36	26,053	141	3	15,720	13,137,720	17,862	54,484	22,273	111
1903....	138	27,573	312	9	21,152	14,029,687	9,796	59,126	25,428	129
1904....	370	17,178	3,113	17	21,702	13,936,475	9,942	69,183	30,856	142
1905....	63	24,606	1,736	31	21,954	13,910,523	14,252	70,101	23,805	57
1906....	105	99,336	189	93	24,974	17,848,284	11,932	64,590	15,358	97
1907....	.....	31,700	.....	.....	24,839	18,706,000	12,063	76,282	.....	.....
1908....	.....	48,000	.....	.....	31,550	18,563,000	15,300	86,985	.....	.....
1909....	.....	54,000	.....	.....	46,664	19,387,000	27,400	86,143	.....	.....
1910....	46	36,360	8,322	17	51,905	18,145,872	23,362	93,548	11,887	427
1911....	129	32,207	3,128	12	86,457	19,740,539	24,585	104,724	17,759	151
1912....	190	39,508	3,277	20	115,286	19,878,477	19,671	112,148	16,800	134
1913....	.....	.....	.....	.....	.....	.....	9,653	.....	.....	.....

Year.	Cobalt Ore.	Iron.					Kaolin.	Lead.		
		Ore.	Pig.	Iron and Steel, Mfrs.	Sulphate.	Oxide.		Ore.	Carbonate.	Pig, Scrap, and Mfrs.
1898....	.....	2,032,240	(b)	47,325	896	1,021	40,352	14,377	1,376	74,902
1899....	.....	1,950,665	(b)	64,178	1,698	1,037	36,904	12,637	2,029	67,149
1900....	.....	2,119,003	149,755	118,152	1,589	1,022	39,842	19,772	1,739	70,857
1901....	.....	1,662,875	61,085	77,742	45	1,001	41,972	15,430	1,789	59,051
1902....	.....	1,563,334	38,521	60,697	17	1,051	41,165	13,121	2,223	58,694
1903....	.....	1,832,820	121,726	119,799	36	1,207	47,534	20,172	2,040	75,416
1904....	.....	1,738,514	135,252	125,709	319	1,151	50,465	25,731	2,221	76,198
1905....	.....	2,151,954	122,102	150,480	709	1,330	52,603	35,103	2,306	73,938
1906....	.....	2,015,550	156,618	342,411	132	1,311	44,772	43,137	2,072	67,651
1907....	1,396	1,999,000	154,031	336,337	.....	.....	53,447	42,342	.....	53,359
1908....	1,500	1,454,000	168,810	373,624	.....	.....	58,909	40,700	.....	70,824
1909....	400	1,202,619	194,225	354,428	.....	.....	59,490	38,400	.....	68,332
1910....	2.6	1,318,520	36,637	378,227	2,243	1,235	62,920	28,950	3,259	64,517
1911....	0.3	1,350,794	49,612	77,000	4,454	1,511	66,500	47,340	3,095	69,791
1912....	.....	1,454,190	57,241	114,100	2,800	1,466	63,783	42,499	2,919	65,449
1913....	.....	.....	.....	.....	.....	.....	61,255	39,772	.....	.....

Year.	Lime, Chloride of.	Manganese Ore.	Nickel.		Petroleum.	Phosphate Rock.	Platinum *Kg.*	Potassium.	
			Ore.	Metal.				Chloride.	Chromate. (*h*)
1898	1,288	100,243	24,935	330	291,961	336,842	505	10,929	2,890
1899	1,887	106,630	28,620	286	306,078	242,021	817	13,335	3,147
1900	1,215	120,790	17,687	299	302,482	283,921	2,398	13,524	3,293
1901	1,400	94,365	39,497	252	225,962	275,285	1,857	13,299	2,784
1902	2,130	85,629	58,374	301	148,170	302,898	2,940	10,802	2,861
1903	919	109,930	13,933	427	(*g*)476,230	343,012	3,764	12,275	2,760
1904	1,679	105,652	20,698	313	(*g*)435,730	419,720	5,650	14,734	2,618
1905	406	140,871	49,698	632	(*g*)512,727	447,738	4,023	21,819	2,619
1906	593	127,235	44,960	480	(*g*)213,462	533,213	5,708	26,523	3,024
1907	.....	192,448	45,892	979	(*g*)311,000	636,549	4,373	.....	.....
1908(*k*)..	.....	170,500	42,200	1,281	(*g*)300,000	767,424	3,955	.....	.....
1909(*k*)..	.....	177,314	12,200	.....	(*g*)300,000	645,178	5,914	.....	.....
1910	333	188,292	28,001	2,074	(*g*)271,500	687,675	7,795	34,974	3,009
1911	53	235,400	43,014	6,465	(*g*)375,000	740,375	9,392	39,508	2,991
1912	24	225,379	27,126	5,032	(*g*)360,000	903,490	6,236	45,174	3,178
1913	.....	258,929	10,292	.....	.....	934,679	.....	.....	.....

Year.	Potassium (*Cont'd*).		Pyrite.	Quicksilver.		Sal Ammoniac.	Salt.	Sodium.	
	Nitrate.	Carbonate.		Ore.	Metal.			Hydrate.	Nitrate.
1899	1,015	2,779	109,696	21	276	12,210	37,970	1,494	9,341,600
1900	1,928	2,768	156,825	22	161	15,205	32,045	1,062	11,995,820
1901	757	2,520	205,617	23	205	9,268	32,347	869	10,526,400
1902	1,547	1,539	170,783	24	224	15,446	32,505	643	9,372,600
1903	1,530	3,019	205,322	20	220	12,462	48,556	781	10,810,775
1904	2,117	3,781	230,097	22	208	13,744	46,232	1,068	9,074,859
1905	1,022	3,542	271,684	.....	228	11,639	45,241	860	11,336,752
1906	684	2,206	349,514	.....	242	18,146	38,361	614	13,678,848
1907	.....	.....	355,300	.....	216	.....	30,000	.....	.....
1908(*k*) ..	.....	.....	348,300	.....	180	.....	33,000	.....	.....
1909(*k*) ..	.....	.....	275,600	.....	191	.....	30,000	.....	.....
1910	132	2,579	309,400	.....	146	27,860	49,800	577	345,160
1911	174	4,452	318,530	.....	196	23,200	47,200	550	317,725
1912	53	4,017	486,072	.....	213	25,056	39,500	556	354,776
1913	.....	.....	186,348	.....	.....	.....	.....	.....	322,115

Year.	Sulphur.	Sulphuric Acid.	Superphosphate of Lime.	Tin.		Zinc.	
				Ore.	Metal.	Ore.	Metal.
1899.....	120,062	4,583	171,631	486	6,907	78,192	25,516
1900.....	133,531	4,254	143,437	512	7,324	66,178	33,144
1901.....	101,301	5,386	165,361	365	7,314	74,553	29,812
1902.....	85,839	7,793	116,093	748	8,575	69,451	36,564
1903.....	109,594	13,241	89,229	1,808	9,873	67,258	39,305
1904.....	148,547	11,212	72,921	1,344	9,352	88,083	35,737
1905.....	129,877	10,915	31,729	1,362	9,898	105,069	29,163
1906.....	131,678	5,268	44,502	1,038	7,687	106,307	26,960
1907.....	106,050	.....	.....	961	7,693	114,699	33,503
1908(*k*).....	195,000	.....	.....	1,000	8,482	137,900	40,312
1909(*k*).....	196,300	.....	.....	1,900	9,683	120,600	32,749
1910.....	202,263	14,642	132,530	1,651	8,517	193,360	19,237
1911.....	267,969	15,150	79,385	2,544	8,456	160,180	42,785
1912.....	172,181	13,169	89,059	1,726	8,503	158,429	43,795
1913.....	8,250	.....	100,882	2,542	.....	178,719	.....

MINERAL AND METALLURGICAL EXPORTS OF FRANCE (a) (b)
(In metric tons)

Year.	Aluminium.	Antimony.		Arsenic.	Cement.	Coal.	Copper.		Gold. Kg. (d)
		Ore.	Metal.				Ore. (c)	Metal.	
1898	192	616	101	.....	241,150	1,320,616	1,783	14,350	1,812
1899	256	304	255	.....	244,480	1,229,090	2,078	17,949	2,622
1900	324	154	336	.....	232,577	1,201,210	9,197	16,791	883
1901	307	645	741	.....	242,010	908,583	16,066	14,776	1,869
1902	748	595	666	.....	210,590	910,760	20,489	14,423	1,517
1903	666	904	1,358	.....	233,835	2,238,735	12,487	11,403	3,139
1904	664	1,191	720	.....	260,686	2,384,928	14,258	12,663	1,537
1905	928	981	815	.....	275,503	(i)3,348,010	13,260	13,800	5,740
1906	1,522	3,541	871	.....	329,879	(i)1,448,000	8,056	6,130	11,727
1907	1,118	3,460	1,270	.....	366,624	(i)1,224,000	4,151	18,630	6,289
1908	1,332	3,300	2,129	8,600	342,131	(i)1,117,000	3,600	17,845	4,455
1909	4,425	4,000	2,408	3,267	316,486	(i)1,493,308	6,200	18,775	5,366
1910	4,148	4,583	2,163	2,411	315,020	(i)1,580,077	4,163	20,884	7,264
1911	4,058	3,991	1,945	832	333,043	(i)1,635,000	8,335	22,690	.....
1912	6,605	1,673	2,890	1,497	361,425	(i)2,320,349	6,374	42,307	775
1913	.....	608	.....	1,850	.....	.....	10,154	.....	.....

Year.	Iron.				Lead.		Manganese Ore.
	Ore.	Pig.	Bars.	Steel.	Ore.	Metal.	
1898	236,169	162,991	27,424	47,278	10,216	3,663	12,229
1899	291,346	153,792	29,112	33,584	3,909	1,163	12,289
1900	371,799	114,361	18,763	19,535	2,345	958	8,392
1901	258,925	96,463	25,220	56,347	3,490	718	5,289
1902	422,677	213,081	23,828	121,932	2,414	648	1,948
1903	714,173	196,444	40,533	215,737	2,313	13,048	717
1904	1,219,149	191,819	40,374	246,738	1,860	13,467	1,392
1905	1,355,932	218,227	67,240	343,612	3,064	12,903	662
1906	1,759,443	143,142	58,826	236,617	1,354	997	4,103
1907	2,147,000	249,708	84,557	291,434	1,210	1,912	5,167
1908	2,384,000	171,797	86,691	360,509	6,700	1,974	1,000
1909	3,907,338	161,058	96,999	318,925	2,800	2,458	1,149
1910	4,892,542	110,086	122,543	(k)302,168	5,855	3,004	722
1911	6,160,100	104,350	171,000	100,000	9,691	2,660	902
1912	8,318,312	216,895	67,000	170,000	12,276	1,660	2,282
1913	.....	.....	.....	.....	14,263	.....	1,705

Year.	Nickel, Refined.	Phosphate Rock.	Plaster.	Pyrite.	Silver, Kg. (e)	Tin (Metal).	Zinc.	
							Ore.	Spelter, Sheets and Scrap.
1899	280	70,517	112,520	53,395	.....	666	76,104	14,958
1900	599	89,135	108,387	64,530	15,470	716	54,663	12,712
1901	1,031	81,405	101,063	52,952	16,745	438	42,995	15,022
1902	397	62,375	110,270	63,920	17,184	654	47,724	16,158
1903	720	72,252	131,245	119,173	43,690	1,994	62,731	12,657
1904	906	78,612	139,551	40,833	23,105	2,300	57,780	19,063
1905	1,583	55,240	124,561	21,257	66,904	2,611	72,512	17,802
1906	1,088	81,660	142,339	26,216	87,952	601	67,258	19,607
1907	1,414	100,508	137,356	24,417	58,199	729	54,316	21,928
1908	1,230	71,509	132,924	40,300	56,957	810	57,800	20,589
1909	1,940	47,611	120,701	40,200	56,549	886	60,000	24,729
1910	2,050	44,384	152,390	56,735	58,294	1,224	56,800	22,975
1911	880	31,413	148,952	68,919	17,256	1,520	51,737	25,500
1912	1,192	22,062	174,486	43,905	3,856	1,450	60,007	34,124
1913	.....	21,128	.....	.....	.....	.....	58,203	.....

(a) From *L'Economiste Francais* (representing the *Commerce Spécial*), except for 1903-06, inclusive, which are from *Tableau Général du Commerce et de la Navigation*. (b) Not reported. (c) Includes matte. (d) Gold and platinum in sheets, leaves, threads or jewelry, and crude platinum. (e) Silver in sheets, leaves, wire, and jewelry. (f) Includes bitumen, bituminous schist and sand, and asphaltic limestone. (g) Crude and refined. Transposition from hectoliters to tons was performed by assuming specific gravity of petroleum to be 0.9. (h) Includes chromate of soda. (i) Includes coke. (k) From *Statistique de l'Industrie Minérale* in the years 1908, 1909, 1910. Steel in 1910 not classified as before. 1911, from *l'Echo des Mines et Metallurgie*.

GERMANY

The mineral production and foreign commerce of the German Empire are given in the following tables in metric tons unless otherwise specified, or in dollars, on the basis of four marks to the dollar. Figures in full-faced type are either provisional figures or estimates.

MINERAL PRODUCTION OF GERMANY (*a*)

Year.	Alum.	Aluminium Sulphate	Arsenic.		Asphaltum.	Boracite.	Cadmium. *Kg.*	Coal.	
			Ore.	Salts.				Bituminous.	Lignitic.
1900	4,355	44,372	4,379	2,415	89,685	232	13,553	109,290,237	40,498,019
1901	4,145	46,807	4,035	2,549	90,193	184	13,144	108,539,444	44,479,970
1902	4,108	47,905	3,959	2,828	88,374	196	12,625	107,473,933	43,126,281
1903	3,934	49,727	4,369	2,768	87,454	159	16,565	116,637,765	45,819,488
1904	3,850	55,881	4,390	2,829	91,736	135	25,245	120,815,503	48,635,080
1905	4,127	52,892	4,913	2,535	103,006	183	24,568	121,298,607	52,512,062
1906	4,494	55,969	6,249	3,052	117,413	161	21,486	137,117,926	56,419,567
1907	4,200	59,473	4,878	2,904	126,649	114	32,949	143,185,691	62,546,671
1908	3,802	53,958	6,065	2,822	89,009	128	32,995	147,671,149	67,615,200
1909	4,179	56,096	6,150	2,911	77,537	149	37,187	148,788,050	68,657,606
1910	4,406	58,349	6,151	3,066	81,208	167	41,100	152,827,777	69,473,883
1911	3,076	.....	4,859	2,981	81,902	160	42,000	160,747,580	73,760,867
1912	.....	.....	4,869	.....	96,117	224	43,000	174,875,297	80,934,797
1913	.....	.....	.....	.....	.....	.....	.....	**191,511,000**	**87,475,000**

Year.	Cobalt, Nickel, and Bismuth Ores.	Copper.				Gold.	Graphite.
		Ore.	Matte. (*b*)	Ingots.	Sulphate.		
1899	1,270	733,619	95	34,634	5,142	$1,731,153	5,196
1900	4,495	747,749	4,207	30,929	5,076	2,030,200	9,248
1901	10,479	777,339	365	31,317	5,192	1,830,835	4,435
1902	12,433	761,921	447	30,578	4,997	1,770,361	5,023
1903	14,607	772,695	583	31,214	5,200	1,709,223	3,720
1904	14,016	798,214	641	30,264	6,584	1,819,538	3,784
1905	10,848	793,488	1,635	31,713	6,988	2,611,812	4,921
1906	.....	768,523	771	32,275	6,757	2,931,750	4,055
1907	2,809	771,227	527	31,946	5,284	3,111,379	4,033
1908	8,535	727,384	328	30,001	7,117	3,162,544	4,844
1909	10,388	798,618	2,242	31,126	6,211	3,366,986	6,774
1910	10,313	925,957	3,735	34,926	5,210	3,227,250	7,415
1911	.....	868,600	1,142	37,452	7,353	3,302,300	11,298
1912	12,861	969,330	2,574	49,447	5,955	**3,322,700**	12,532

Year.	Iron and Steel.				Lead.		
	Iron Ore.	Pig Iron. (*c*)	Wrought Iron and Steel.	Sulphate. (*d*)	Ore.	Pig.	Litharge.
1899	17,989,635	8,153,133	7,532,524	10,931	144,370	129,225	3,562
1900	18,964,294	8,520,540	7,377,275	10,913	148,257	121,513	3,088
1901	16,570,182	7,880,087	7,033,438	11,148	153,341	123,098	4,101
1902	17,963,591	8,529,900	8,317,231	.....	167,855	140,331	4,197
1903	21,230,650	10,017,901	9,226,898	12,243	165,991	145,319	4,428
1904	22,047,393	10,058,273	9,239,302	13,585	164,440	137,580	4,332
1905	23,444,073	10,875,061	10,309,690	12,949	152,725	152,590	3,786
1906	26,734,570	12,292,819	11,307,807	13,376	140,914	150,741	4,137
1907	27,697,127	12,875,159	12,063,632	14,033	147,272	142,271	4,325
1908	24,278,151	11,805,321	10,930,933	15,738	156,861	164,079	5,339
1909	25,505,409	12,917,653	11,719,239	21,838	159,852	167,920	3,059
1910	28,709,700	14,502,183	12,988,177	18,677	148,497	159,851	3,581
1911	29,879,361	15,280,527	14,384,271	17,002	140,154	161,287	3,687
1912	27,199,944	15,220,881	16,508,987	.....	142,839	192,618	4,135

Year.	Magnesium Salts.		Manganese Ore.	Petroleum.	Potassium Salts.				
	Chloride.	Sulphate.			Chloride.	Kainite. (f)	Sulphate.	Potassium-Magnesium Sulphate.	Other than Kainite.
1899	21,370	39,540	61,329	27,027	207,506	1,108,159	26,103	9,765	1,384,972
1900	19,397	48,591	59,204	50,375	271,512	1,227,873	30,853	15,368	1,822,758
1901	21,018	46,714	56,691	44,095	294,666	1,498,569	37,394	15,612	2,036,325
1902	19,658	39,262	49,812	49,725	267,512	1,322,623	28,278	18,147	1,962,384
1903	22,990	37,844	47,994	62,680	280,248	1,557,243	36,674	23,631	2,073,720
1904	25,730	39,412	52,886	89,620	297,238	1,905,893	43,959	29,285	2,179,471
1905	29,017	58,568	51,463	78,869	373,177	2,387,643	47,994	34,222	2,655,845
1906	38,468	43,041	52,485	81,350	403,387	2,720,594	54,490	35,211	2,821,073
1907	32,891	41,105	73,105	106,379	473,138	2,624,412	60,292	33,368	3,124,955
1908	29,775	42,977	67,692	141,900	511,258	2,715,487	55,756	33,149	3,383,535
1909	31,526	53,812	77,177	143,244	624,994	3,181,349	68,539	38,722	3,969,554
1910	32,207	57,314	80,560	145,168	741,259	4,249,667	84,583	37,438	4,062,004
1911	36,764	55,179	87,297	142,992	838,420	4,425,497	107,631	42,253	5,181,379
1912	85,387	99,442	185	134,986	506,744	5,889,238	123,407	54,435	.....

Year.	Pyrite.	Salt.		Silver and Gold Ore.	Silver. *Kg.*	Sodium Sulphate.	Sulphur.	Sulphuric Acid.
		Rock.	Evaporated.					
1899	144,623	861,123	571,058	13,506	467,590	79,062	1,663	813,141
1900	169,447	926,563	587,464	12,593	415,735	90,468	1,445	829,376
1901	157,433	985,050	578,751	11,577	403,796	76,066	963	835,000
1902	165,225	1,010,412	572,846	11,724	430,610	90,742	.....	894,409
1903	170,867	1,095,541	598,394	11,467	396,253	83,087	219	928,190
1904	174,782	1,079,868	621,064	10,405	389,827	75,171	209	963,384
1905	185,368	1,165,495	612,062	10,286	399,775	68,454	205	1,228,211
1906	196,971	1,235,041	635,171	8,066	393,442	81,175	178	1,335,128
1907	196,351	1,285,137	665,547	8,280	386,933	80,347	176	1,402,398
1908	219,456	1,331,984	665,651	7,653	407,185	72,667	811	1,391,653
1909	198,688	1,370,668	647,939	7,510	400,562	71,813	1,185	1,434,709
1910	215,708	1,424,064	669,120	6,646	420,003	84,787	1,272	1,616,336
1911	217,459	1,436,492	645,991	4,890	439,580	82,664	1,251	1,534,453
1912	242,121	1,352,524	671,622	595	.....	.....	.....	1,649,681

Year.	Tin.			Uranium and Tungsten Ores.	Zinc.		
	Ore.	Block.	Chloride.		Ore.	Spelter.	Sulphate.
1900	80	2,031	(g) 143	43	639,215	155,790	6,027
1901	82	1,464	(g) 135	43	647,496	166,283	5,552
1902	104	2,779	.....	31	702,504	174,927	.....
1903	110	3,065	1,064	35	682,853	182,548	5,994
1904	99	4,216	816	23	715,732	193,058	6,185
1905	123	5,233	811	26	731,271	198,208	5,896
1906	.....	6,597	987	.....	704,590	205,691	6,092
1907	.....	5,838	1,812	3	698,425	208,195	5,145
1908	111	6,374	2,266	42	706,441	216,490	5,310
1909	124	8,994	3,247	98	723,565	219,766	5,574
1910	125	11,395	3,391	95	718,316	221,395	6,308
1911	.....	12,412	3,749	.....	699,970	235,776	6,703
1912	(i)	10,646	3,094	70	643,598	269,161	6,413
1913	.....	.....	.....	.....	637,308	283,190	.....

(a) From the *Vierteljahrshefte zur Statistik des Deutschen Reichs.* Where gold is reported, 1 mark = $0.238. (b) Includes black copper. (c) Includes ferro manganese and spiegeleisen. (d) Contains a small quantity of copper and iron sulphate mixed. (f) Compound of potassium chloride and magnesium sulphate. (g) Includes nickel sulphate. (i) Included with cobalt, nickel and bismuth.

MINERAL PRODUCTION OF BADEN (a)
(In metric tons or dollars; 4 marks = $1)

Year.	Aluminium Sulphate.	Barytes.	Coal.	Gypsum.	Manufacturers of Iron.		
					Cast, Foundry.	Steel.	Wrought.
1899....	2,153	2,430	4,700	29,419	53,608	3,830	1,402
1900....	2,286	2,970	4,930	26,381	50,102	3,532	1,364
1901....	2,260	3,991	3,650	28,183	40,100	8,739	1,158
1902....	2,374	6,234	2,078	33,150	40,973	12,663	1,052
1903....	2,498	8,857	1,990	29,423	45,233	7,666	863
1904....	2,392	9,078	1,485	26,984	64,320	7,687	783
1905....	2,581	11,094	668	28,823	74,128	8,053	842
1906....	2,583	11,984	1,000	25,643	81,387	11,068	466
1907....	2,644	9,303	2,075	29,153	98,430	10,818	533
1908....	2,524	(c) 8,554	2,473	35,217	83,724	10,430	602
1909....	2,329	(c) 15,186	2,356	36,621	83,458	11,643	484
1910....	2,141	(c) 13,832	1,650	41,078	95,795	12,134	239
1911....	2,554	15,014	(b)	42,408	107,784	11,909	244
1912....	.....	15,871	.....	51,778	.....	.....	.....
1913....	.....	16,445	.....	49,767	.....	.....	.....

Year.	Lead Ores.	Salt.	Sulphuric Acid.	Tripoli.	Zinc Ore.
1899.....	(b)	31,197	13,660	12	357
1900.....	67	32,699	15,938	9	3,004
1901.....	369	32,835	17,081	8	2,870
1902.....	450	32,192	19,265	11	2,958
1903.....	350	32,383	19,755	11	3,171
1904.....	265	32,148	35,517	12	5,063
1905.....	264	31,393	40,781	12	4,046
1906.....	246	31,288	38,655	15	1,466
1907.....	278	32,078	42,831	25	2,198
1908.....	329	33,993	41,455	13	2,793
1909.....	372	34,040	42,219	14	3,253
1910.....	419	32,729	56,069	7	3,345
1911.....	191	32,118	47,796	14	3,067
1912.....	428	32,326	.....	14	3,730
1913.....	480	33,502	.....	13	3,882

(a) From the *Uebersicht der Production des Bergwerks-, Hütten-, und Salinen-Betriebes in dem Badschen Staate.* (b) Not reported. (c) Includes fluorspar.

MINERAL PRODUCTION OF BAVARIA (a)
(In metric tons; 4 marks = $1)

Year.	Barytes.	Kaolin.	Coal.	Coal (Lignite).	Copperas and Other Sulphate.	Emery.	Feldspar.	Fluor-spar.	Graphite.
1899..	6,214	25,822	1,004,421	35,736	900	399	287	3,631	5,196
1900..	10,515	58,795	1,185,296	39,165	916	414	460	7,456	9,248
1901..	8,711	35,450	1,203,792	25,224	590	366	788	5,220	4,435
1902..	8,034	92,073	1,233,568	27,337	691	225	447	5,460	5,023
1903..	8,642	88,140	1,356,556	25,189	814	220	1,060	3,410	3,719
1904..	9,411	95,160	1,341,925	53,517	893	265	1,866	4,770	3,784
1905..	10,030	99,910	1,317,951	154,128	844	255	1,710	4,413	4,921
1906..	19,817	98,138	1,381,175	140,290	836	320	1,740	5,570	4,055
1907..	21,500	115,387	1,495,895	286,256	850	326	2,125	4,780	4,033
1908..	17,195	68,551	647,639	1,209,110	910	245	5,859	5,480	4,844
1909..	17,920	187,312	694,191	1,242,088	1,094	305	3,151	5,580	6,774
1910..	24,711	107,660	713,994	1,299,970	1,333	270	2,620	5,132	7,415
1911..	26,234	70,512	763,172	1,548,465	.....	210	3,165	4,680	11,298
1912..	27,199	72,517	790,680	1,704,654	.....	260	6,666	4,220	12,532
1913..	.....	.....	**811,000**	**1,895,000**	.....	.....	.....	.....	.....

Year.	Gypsum.	Iron.						Lithographic Limestone.
		Ore.	Bar.	Cast, 1st Fusion.	Cast, 2d Fusion.	Pig.	Steel.	
1899....	29,727	181,981	61,415	(b)	92,459	83,821	134,007	11,962
1900....	35,484	178,441	49,727	29	89,692	82,327	135,411	16,030
1901....	3,581	158,820	29,978	76	76,191	72,071	109,464	9,500
1902....	31,701	157,375	38,429	56	81,874	83,123	115,354	.....
1903....	30,894	162,500	36,853	41	89,804	90,168	127,141	9,890
1904....	22,766	180,342	37,780	40	108,025	92,200	125,483	13,836
1905....	46,247	182,389	36,459	24	112,875	94,242	134,755	11,380
1906....	50,763	203,596	38,508	.....	122,115	97,812	150,129	.....
1907....	48,975	277,280	36,883	*Nil.*	138,659	98,143	150,148	11,590
1908....	51,314	278,681	30,740	*Nil.*	128,234	131,404	176,085	9,858
1909....	51,630	279,514	33,448	*Nil.*	130,129	134,133	219,606	9,420
1910....	54,397	303,844	30,881	*Nil.*	148,261	133,679	249,198	9,790
1911....	60,390	375,409	165,683	*Nil.*	171,976	.....	339,401	8,175
1912....	57,114	450,074	(c)	.....	396,656	195,606	998,624	9,903

Year.	Marl. (For Cement)	Mineral Paint and Chalk.	Pyrites.	Rock Salt.	Soapstone.	Sodium Sulphate.	Sulphuric Acid.
1899....	220,716	9,287	2,516	802	2,197	1,570	123,273
1900....	180,032	11,507	2,120	1,298	1,977	1,821	123,910
1901....	76,663	84,929	2,649	1,319	2,291	1,893	115,775
1902....	178,301	13,947	2,635	832	.....	.....	.....
1903....	200,407	19,486	2,324	879	1,866	.....	.....
1904....	170,698	19,107	3,427	1,139	1,709	.....	.....
1905....	231,310	18,285	3,301	911	1,872	.....	.....
1906....	230,271	22,304	3,918	1,053	.....	.....	.....
1907....	230,583	21,219	5,085	1,393	1,999	1,439	161,868
1908....	307,820	21,310	4,037	1,285	2,199	1,743	149,079
1909....	276,974	21,692	2,952	1,860	2,329	1,265	178,371
1910....	273,727	22,357	4,466	1,192	3,083	1,416	171,131
1911....	265,899	24,258	6,316	782	3,431	2,061	170,039
1912....	341,068	30,033	6,531	1,162	3,221	.....	254,708

(a) From the *Uebersicht der Production des Bergwerks-, Hütten-, und Salinen-Betriebes in dem Bayerischen Staate.* (b) Not reported. (c) With cast iron.

MINERAL PRODUCTION OF PRUSSIA (a)

(Metric tons; 4 marks = $1)

Year.	Alum Shale.	Antimony and Alloys.	Arsenic Products.	Arsenic Ore.	Asphalt.	Boracite.	Cadmium. *Kg.*	Coal.
1900....	103	3,025	1,585	3,531	23,891	217	13,533	101,966,158
1901....	611	2,404	1,446	3,050	26,450	164	13,144	101,203,807
1902....	219	3,542	1,514	2,909	28,035	172	12,625	100,115,315
1903....	580	3,224	1,583	3,538	23,518	135	16,565	108,809,384
1904....	106	2,774	1,573	3,527	26,348	115	25,245	112,755,621
1905....	97	2,795	1,493	4,022	28,872	151	24,568	113,000,657
1906....	634	2,953	1,551	5,430	32,270	124	21,486	128,295,948
1907....	154	3,515	1,591	4,224	39,243	90	32,949	134,044,080
1908....	80	3,596	1,646	5,015	27,444	105	32,995	139,002,378
1909....	60	3,841	1,849	5,731	19,509	123	37,187	139,906,194
1910....	46	4,969	2,068	5,789	21,595	138	41,058	143,771,612
1911....	63	5,411	1,862	4,476	19,956	147	42,575	151,324,030
1912....	104	.....	.....	4,870	21,241	186	.....	165,302,784
1913....	180	.....	.....	5,008	17,795	160	.....	179,861,015

ar.	Coal (Lignite).	Cobalt Ore.	Cobalt Products.	Copper.	Copper and Iron Sulphate.	Copper Ore.	Copper Matte.
....	34,007,542	4	52	27,156	113	747,601	4,207
....	37,491,412	36	66	28,422	78	765,241	281
....	36,228,285	76	74	27,893	119	751,496	346
....	38,462,766	65	87	28,386	110	761,188	488
....	41,153,576	41	85	27,450	95	782,049	601
....	44,148,751	22	99	28,874	102	769,381	1,052
....	47,912,721	7	98	29,166	94	755,812	525
....	52,660,597	*Nil.*	109	28,945	64	755,203	499
....	55,456,860	*Nil.*	100	27,301	50	711,921	296
....	56,029,554	*Nil.*	93	28,523	55	798,448	1,935
....	56,644,291	*Nil.*	94	30,244	44	914,519	2,060
....	60,531,943	*Nil.*	107	30,986	27	919,827	996
....	65,803,959	*Nil.*	.....	.....	.....	967,785	.....
....	70,051,871	*Nil.*	.....	.....	.....	941,402	.....

ear.	Copper Sulphate.	Epsom Salt.	Gold. *Kg.*	Iron.	Iron Ore.	Iron Sulphate.	Lead.
.....	1,660	1,511	1,076.6	5,781,892	4,268,069	10,225	112,738
.....	1,951	1,952	1,087.1	5,315,628	3,831,670	10,239	113,939
.....	1,937	761	1,138.0	5,633,089	3,362,887	11,214	127,283
.....	2,254	421	949.5	6,614,768	3,786,743	11,086	133,405
.....	3,364	289	1,081.9	6,573,507	3,757,651	12,524	128,294
.....	3,065	338	1,034.9	7,106,975	4,130,210	12,075	143,270
.....	2,724	144	750.2	8,154,880	4,713,928	12,473	140,690
.....	2,129	263	771.0	8,266,300	5,077,773	13,014	132,366
.....	3,116	398	786.6	7,989,260	4,311,593	14,062	153,541
.....	2,500	395	588.2	8,410,824	4,389,950	18,295	156,533
.....	1,749	162	566.3	9,995,012	4,823,606	16,119	146,993
....	2,464	114	520.	10,477,263	4,948,711	15,468	147,538
.....	.....	.....	.....	.....	5,331,240	.....	.....
.....	.....	.....	.....	.....	5,461,670	.....	.....

Year.	Lead Ore.	Litharge.	Manganese Ore.	Nickel.	Nickel Ore.	Nickel Sulphate.	Ocher and Mineral Paints.
.....	133,483	2,366	58,016	1,376	3,896	115	2,850
.....	139,285	2,885	55,866	1,660	9,922	120	2,800
.....	152,282	2,516	48,882	1,605	11,816	159	2,780
.....	151,746	2,710	47,110	1,945	14,058	173	2,850
.....	150,328	2,517	52,092	2,333	13,518	207	3,200
.....	138,928	2,272	51,048	2,631	10,432	220	3,170
.....	127,322	2,744	51,881	2,648	7,472	187	3,635
.....	133,528	2,959	72,442	2,093	7,557	189	3,707
.....	141,316	4,190	67,241	2,622	8,238	181	3,183
.....	158,811	2,365	76,741	3,186	10,095	163	3,435
.....	146,830	3,076	80,325	3,497	10,053	213	142
.....	135,366	3,441	86,902	3,744	9,609	244	.....
.....	140,158	.....	92,474	.....	12,091	.....	.....
.....	143,799	.....	(*b*)	.....	13,538	.....	.....

Year.	Petroleum.	Potassium Salts.		Pyrite.	Quicksilver. *Kg.*	Salt.	
		Kainite.	All Other.			Common.	Rock.
1900.....	27,731	857,271	1,264,993	159,186	1,711	287,005	354,603
1901.....	24,098	1,068,237	1,131,703	148,457	1,713	290,869	353,557
1902.....	29,520	943,450	1,344,541	155,410	1,828	291,296	359,006
1903.....	41,733	1,118,270	1,344,038	159,234	2,145	317,475	409,199
1904.....	67,604	1,261,930	1,447,323	163,209	3,030	328,933	394,910
1905.....	57,741	1,580,530	1,734,033	174,641	2,597	328,051	436,942
1906.....	59,196	1,923,088	1,937,181	186,849	5,084	339,675	492,339
1907.....	80,255	1,839,409	2,070,978	184,962	5,080	353,290	480,563
1908.....	113,002	2,037,203	2,192,188	204,992	4,423	359,003	478,346
1909.....	113,518	2,431,401	2,436,319	189,773	5,213	344,685	491,071
1910.....	110,996	3,119,400	2,584,565	203,596	4,492	351,698	500,978
1911.....	98,611	3,502,762	2,920,725	203,249	2,861	337,583	527,034
1912.....	87,443	4,256,476	3,287,177	233,397	.....	343,883	527,275
1913.....	71,178	4,426,054	3,658,109	228,405	.....	353,260	526,218

Year.	Silver. *Kg.*	Silver and Gold Ores.	Sulphur.	Sulphuric Acid.	Tin.	Zinc.		
						Ore.	Metal.	Sulphate.
1900.....	266,577	1	1,207	593,109	2,010	636,068	155,760	3,742
1901.....	246,286	6	772	609,041	1,443	644,504	166,223	3,369
1902.....	273,901	17	250	677,798	2,753	699,392	174,892	3,381
1903.....	255,722	13	16	724,784	3,042	679,320	182,472	3,588
1904.....	252,020	8	16	868,424	4,193	710,599	192,903	3,696
1905.....	266,072	4	14	921,219	5,196	727,104	198,179	3,506
1906.....	264,427	239	16	980,188	6,570	702,933	205,632	3,530
1907.....	249,348	34	7	1,004,599	5,819	696,039	207,849	3,057
1908.....	274,154	7	706	997,931	5,330	703,394	212,991	3,223
1909.....	271,779	2	1,096	1,006,787	8,943	720,139	214,551	3,434
1910.....	277,777	0.2	1,239	1,164,015	11,345	714,855	216,362	3,875
1911.....	277,981	.....	1,239	1,219,879	12,335	696,903	230,995	4,127
1912.....	.....	.....	.....	.....	.....	647,081	.....	.....
1913.....	.....	.....	.....	.....	.....	649,695	.....	.....

(*a*) From *Zeitschrift für das Berg, Hütten, und Salinenwesen.*
(*b*) Included in "Iron Ore."

MINERAL IMPORTS OF GERMANY (*a*)

Year.	Aluminium Refined and Crude.	Ammonium Sulphate.	Antimony.	Antimony and Arsenic Ores.	Asbestos, Crude.	Asphalt.	Bituminous Rock.	Barium Chloride.	Barytes. (*b*)
1901 ...	1,090	44,408	1,494	1,098	5,500	62,299	41,733	1,768	5,754
1902 ...	1,100	42,252	1,495	1,231	3,415	88,536	36,791	2,135	5,040
1903 ...	1,155	35,168	2,281	1,741	5,727	94,377	40,873	2,374	5,534
1904 ...	2,422	35,166	2,003	1,687	5,251	85,049	38,812	2,428	6,742
1905 ...	3,252	48,005	1,680	567	7,830	3,461	64,196	2,114	7,981
1906 ...	3,886	35,366	2,044	2,417	9,828	15,095	118,238	2,559	17,248
1907 ...	3,974	33,522	2,496	4,913	11,096	4,793	128,257	2,781	12,388
1908 ...	3,204	47,265	2,670	2,073	10,034	2,587	130,063	2,256	19,969
1909 ...	8,696	58,132	2,719	2,912	11,928	1,209	98,378	1,907	14,560
1910 ...	9,892	31,400	2,982	3,347	11,729	2,932	117,763	1,955	5,782
1911 ...	10,454	24,463	3,607	6,429	12,334	133,635	17,476	2,002	7,928
1912 ...	18,112	23,098	3,400	2,891	14,790	147,784	18,409	3,674	18,668
1913 ...	15,508	34,627	3,604	3,700	14,658	145,351	.....	2,598	19,486

Year.	Borax.	Bauxite.	Calcium Carbide.	Cement.	Chalk (*d*), Crude White.	Chrome Ore.	Coal.		Coke.
							Bitum., Arthracite, Cannel.	Lignitic.	
1901 ...	2,537	24,113	9,526	87,262	(*d*)29,611	18,222	6,297,389	8,108,943	400,197
1902 ...	2,057	26,698	11,287	52,018	(*d*)26,408	10,152	6,425,658	7,882,010	382,488
1903 ...	2,567	22,316	14,081	49,870	(*d*)33,362	13,919	6,766,513	7,962,123	432,819
1904 ...	2,603	27,849	14,840	60,188	(*d*)32,581	18,132	7,299,042	7,669,099	550,302
1905 ...	2,802	39,137	17,256	148,118	(*d*)35,529	11,998	9,399,693	7,945,261	713,619
1906 ...	3,044	43,177	22,819	233,119	18,871	17,124	9,253,711	8,430,441	565,561
1907 ...	2,014	59,989	25,834	241,475	16,035	19,508	13,729,849	8,963,103	584,220
1908 ...	1,903	48,064	29,024	168,504	17,606	16,974	11,661,503	8,581,966	575,091
1909 ...	2,550	45,543	26,956	224,178	15,924	22,018	12,198,634	8,166,479	673,012
1910 ...	3,181	56,287	30,712	242,663	17,700	24,470	11,195,593	7,397,719	622,452
1911 ...	5,358	37,155	36,994	253,023	23,717	16,022	10,913,948	7,069,064	598,958
1912 ...	7,978	36,348	47,984	228,896	28,031	23,201	10,380,482	7,266,116	589,713
1913 ...	7,381	38,452	46,725	168,449	32,546	23,251	10,540,018	6,986,681	592,661

Year.	Peat and Peat Coke.	Briquettes.	Cobalt and Nickel Ore.	Copper.				Copperas	Cryolite.
				Ore. and Matte.	Ingots.	Bars, Wire and Sheets.	Sulphate.		
1901 ...	15,102	92,037	12,186	4,614	58,620	786	1,211	501	1,249
1902 ...	16,696	81,854	14,630	14,630	76,050	540	2,499	807	1,332
1903 ...	14,640	84,635	36,927	13,714	83,261	568	1,691	778	1,082
1904 ...	9,071	125,477	14,555	7,949	110,231	719	1,735	765	1,139
1905 ...	11,439	191,753	39,590	10,137	102,218	927	2,180	666	1,143
1906 ...	19,428	162,650	22,557	9,941	126,071	409	1,702	621	(*k*)
1907 ...	15,238	195,403	29,296	19,295	124,116	772	4,519	1,165	(*k*)
1908 ...	15,266	192,391	17,402	17,456	157,669	952	5,078	7,234	(*k*)
1909 ...	13,208	211,058	10,186	26,488	154,673	416	6,550	5,954	(*k*)
1910 ...	16,188	241,267	9,937	22,194	181,551	403	3,952	4,336	(*k*)
1911 ...	14,517	210,933	14,897	23,327	191,590	520	4,145	3,323	(*k*)
1912 ...	11,040	187,736	14,987	23,192	200,608	332	7,074	5,925	(*k*)
1913 ...	11,796	147,416	13,658	27,594	225,392	.....	3,869	2,954	(*k*)

Year.	Gold, Silver and Platinum Ores.	Graphite	Gypsum.	Iodine.	Iron.		Lead.		
					Ore.	Pig.	Ore.	Pig and Scrap.	Lead White.
1901 ...	8,764	17,374	7,622	266	4,370,022	267,503	100,196	52,886	423
1902 ...	6,585	19,392	8,177	220	3,957,403	143,040	71,078	39,006	357
1903 ...	4,386	20,953	8,328	320	5,225,336	158,347	67,573	52,440	442
1904 ...	5,960	23,533	9,550	272	6,061,127	178,256	83,807	61,388	622
1905 ...	6,225	26,143	11,247	377	6,085,196	158,700	92,667	78,528	2,488
1906 ...	4,819	28,175	11,062	297	7,629,730	409,083	90,027	71,191	2,342
1907 ...	3,601	29,405	14,662	147	8,476,076	443,624	137,861	75,200	3,037
1908 ...	1,922	34,491	14,599	194	7,732,949	252,779	133,597	77,218	3,558
1909 ...	1,759	29,191	11,285	369	8,366,599	134,230	111,017	76,930	2,890
1910 ...	2,552	30,733	10,873	363	9,816,822	136,330	112,151	81,541	2,780
1911 ...	2,947	32,812	11,973	303	10,812,595	129,850	143,598	100,515	3,938
1912 ...	2,200	37,633	10,628	260	12,120,090	135,722	122,847	93,585	2,709
1913 ...	1,932	37,168	8,818	258	14,019,045	124,236	142,977	83,781	1,980

Year.	Magnesite.	Manganese Ore.	Mineral Pigments.	Nickel.	Ozokerite.	Petroleum Products		Phosphorus.
						Illuminating Oil.	Lubricating Oil.	
1901....	8,897	204,420	9,403	1,947	1,981	985,904	118,999	313
1902....	12,237	222,010	7,719	1,458	1,585	1,006,829	125,667	350
1903....	14,958	204,647	9,888	1,507	1,663	1,067,697	147,837	222
1904....	15,877	223,709	10,494	1,712	1,300	1,076,324	142,929	220
1905....	19,459	255,760	11,473	1,955	1,114	1,070,252	143,926	198
1906....	25,527	262,311	3,960	3,478	1,303	984,134	180,989	208
1907....	30,857	331,171	2,166	2,182	1,653	1,115,205	226,609	165
1908....	28,305	393,327	1,635	3,058	1,447	1,123,632	216,887	141
1909....	29,994	334,133	13,804	3,745	1,447	1,085,839	216,987	179
1910....	40,218	384,445	15,100	4,606	1,729	1,135,886	230,516	169
1911....	47,930	487,872	15,703	2,598	1,591	955,482	260,242	200
1912....	69,064	420,709	17,874	2,027	1,479	795,011	241,030	205
1913....	64,974	680,371	18,971	3,315	1,363	745,466	248,035	209

Year.	Phosphate Rock.	Potassium Salts.							Pumice Stone. (g)	Pyrite.
		Chloride.	Cyanide. (f)	Iodide.	Nitrate.	Carbonate.	Hydroxide.	Sulphate.		
1901....	351,155	462	2	1,529	1,758	1,529	165	680	2,336	488,633
1902....	430,043	261	3	10	1,889	2,112	42	266	2,070	452,095
1903....	461,092	40	3	8	2,163	1,850	52	81	2,697	519,317
1904....	508,634	47	2	10	2,349	1,955	61	121	3,000	503,503
1905....	501,048	223	3	30	2,156	1,693	24	131	3,240	552,184
1906....	531,195	181	3	18	1,918	2,099	44	257	5,463	579,355
1907....	579,505	1,615	1	8	1,815	2,304	92	141	5,443	742,326
1908....	736,127	49	4	7	2,200	1,773	50	169	6,154	659,871
1909....	663,400	55	2	4	2,853	1,750	64	101	6,639	691,213
1910....	723,271	72	2	8	1,979	2,366	63	66	7,446	792,735
1911....	831,027	1,160	33	13	2,114	2,616	67	61	9,659	862,214
1912....	902,844	46	5	11	597	2,321	62	44	8,365	1,073,285
1913....	928,798	15	3	13	402	2,760	42	44	8,801	1,023,932

Year.	Quicksilver.	Salt.	Slag and Slag Wool.	Sodium Salts.			Strontianite. (n)
				Soda, Calcined.	Nitrate (Chile Saltpeter).	Sulphate and Sulphite.	
1901.....	651	23,901	733,931	178	529,568	7,921	19,739
1902.....	648	26,404	831,282	121	467,024	7,308	34,035
1903.....	674	20,118	877,394	114	467,130	6,058	24,183
1904.....	691	18,743	846,738	179	506,172	9,598	18,055
1905.....	729	20,726	888,665	143	540,916	4,752	13,720
1906.....	698	16,997	813,388	189	593,218	7,405	5,212
1907.....	831	23,109	568,046	257	591,131	10,446	5,595
1908.....	648	24,975	562,853	293	604,457	4,404	4,211
1909.....	723	19,319	492,771	181	665,450	9,214	4,277
1910.....	836	30,443	766,320	105	749,945	9,302	4,852
1911.....	919	29,067	685,943	559	730,939	5,976	3,551
1912.....	990	17,887	1,248,693	1,987	812,898	5,609	4,259
1913.....	961	21,422	.....	2,633	774,298	10,074	3,965

Year.	Sulphur.	Sulphuric Acid.	Super-phosphate.	Tin, Crude.	Zinc.			
					Ore.	Spelter.	Drawn or Rolled.	Zinc White, Zinc Gray, Lithophone.
1901....	32,750	18,502	107,365	12,910	75,533	21,250	306	3,673
1902....	32,798	22,205	109,374	13,760	61,407	25,946	134	3,986
1903....	41,545	13,418	82,740	13,925	67,156	25,749	237	4,667
1904....	41,030	16,087	91,288	14,352	93,515	26,389	151	6,461
1905....	39,989	33,837	109,666	13,501	126,577	29,583	54	7,802
1906....	41,390	74,536	76,384	14,098	178,953	39,314	97	9,140
1907....	44,700	59,753	62,877	12,814	184,703	28,459	134	10,189
1908....	44,066	61,391	71,879	14,039	199,840	32,622	286	7,080
1909....	42,941	74,384	80,512	13,537	201,110	44,514	99	7,002
1910....	46,796	86,743	78,873	14,297	240,584	39,328	246	9,239
1911....	46,054	99,653	71,119	14,500	262,399	48,355	467	7,697
1912....	42,284	98,573	62,400	15,550	293,090	56,937	1,003	9,367
1913....	46,737	130,257	53,193	14,261	313,269	57,641	725	9,108

MINERAL EXPORTS OF GERMANY (a)

Year.	Aluminium Refined and Crude.	Aluminium Wares, etc.	Aluminium Sulphate.	Ammonium.		Antimony and Arsenic Ores.	Antimony.	
				Carbonate and Chloride.	Sulphate.		Metallic.	Salts.
1901....	282	2,270	31,171	3,196	9,842	283	76	826
1902....	410	2,608	34,005	3,351	5,744	410	105	954
1903....	353	2,865	28,513	2,778	5,592	427	83	873
1904....	407	3,077	29,311	3,106	10,696	486	250	964
1905....	1,192	3,476	34,776	3,579	27,589	287	218	1,097
1906....	1,111	1,321	25,937	3,555	37,288	548	221	997
1907....	1,119	1,142	24,759	3,118	57,439	930	255	1,168
1908....	590	642	22,376	1,161	73,186	588	146	1,030
1909....	492	1,273	58,723	1,093	58,722	577	160	1,090
1910....	616	1,755	93,069	1,500	93,069	571	198	1,047
1911....	768	1,331	30,107	4,895	74,410	612	298	1,208
1912....	2,074	4,184	32,469	5,292	57,268	569	132	1,155
1913....	2,703	5,667	31,772	5,401	75,868	502	702	1,461

Year.	Arsenic.		Asbestos.	Barytes. (b)	Barium.		Bauxite.	Borax.	Bromine.
	Metallic.	White, etc.	Crude.		Chloride and Salts of.	White.			
1901 ...	28	1,534	638	67,526	6,803	2,765	137	2,563	228
1902 ...	46	2,036	709	56,026	7,358	2,922	32	2,836	153
1903 ...	32	1,903	513	72,455	8,417	3,187	19	2,779	155
1904 ...	50	1,956	738	69,564	8,596	3,777	21	2,741	208
1905 ...	40	1,753	1,173	81,134	9,550	4,382	6	2,720	156
1906 ...	.....	2,282	1,938	90,819	6,541	10,721	398	2,795	172
1907 ...	(m)45	1,733	1,707	111,209	4,189	8,454	517	3,049	118
1908 ...	(m)65	1,956	1,345	91,111	3,389	5,190	783	2,379	227
1909 ...	(m)54	1,012	1,740	90,555	5,340	4,888	1,116	2,735	206
1910 ...	(m)57	1,507	1,537	114,264	6,403	5,528	863	2,916	225
1911 ...	71	1,973	1,503	128,452	6,180	6,834	960	3,199	229
1912 ...	73	2,400	1,891	142,957	7,389	8,298	400	3,330	187
1913 ...	.....	2,612	1,461	158,065	5,649	7,647	355	3,433	239

Year.	Coke.	Peat and Peat Coke.	Briquets.	Cobalt and Nickel Ore.	Copper.			
					Ore and Matte.	Bars, Sheets and Wire.	Ingots.	Sulphate.
1901....	2,096,931	11,588	529,765	96	26,678	7,700	5,097	1,942
1902....	2,182,383	13,410	697,799	3	17,031	10,599	4,678	1,366
1903....	2,523,351	16,986	895,145	1	15,986	10,715	4,333	1,880
1904....	2,716,855	14,830	917,526	83	19,235	12,594	4,223	2,231
1905....	2,761,080	16,009	936,694	107	28,908	10,006	5,958	2,180
1906....	3,415,347	15,680	1,095,029	(i)	6,414	10,728	7,241	3,018
1907....	3,792,580	25,746	1,260,135	(i)	20,950	13,411	6,113	2,016
1908....	3,577,496	26,817	1,493,054	(i)	21,729	17,209	6,868	2,994
1909....	3,444,791	23,579	1,620,460	(i)	22,437	15,395	6,495	1,290
1910....	4,125,898	20,360	1,988,177	(i)	23,751	19,351	7,654	2,108
1911....	4,555,477	35,855	2,477,492	(i)	27,396	19,669	7,106	3,346
1912....	5,850,350	60,557	2,746,536	(i)	21,514	20,245	7,854	3,812
1913....	6,411,418	86,920	3,163,742	(i)	25,221	.....	7,208	4,013

Year.	Bromine Salts.	Calcium.		Cement.	Chalk, Crude White.	Chromium.		Coal.	
		Carbide.	Chloride.			Ore.	Alum.	Bituminous, Anthracite and Cannel.	Lignite
1901 ...	249	275	888	560,612	(d)14,134	581	1,299	15,269,267	21,718
1902 ...	357	126	1,346	699,378	(d) 8,475	846	1,758	16,101,141	21,766
1903 ...	435	335	1,831	742,381	(d)12,211	37	1,921	17,389,934	22,499
1904 ...	411	608	2,381	635,248	(d)11,359	47	2,432	17,996,726	22,135
1905 ...	634	709	2,831	675,664	(d)13,081	43	2,507	18,156,998	20,118
1906 ...	643	545	(l)	736,579	4,287	(h) 36	2,942	19,550,964	18,759
1907 ...	655	918	(l)	692,982	2,919	(h) 149	3,110	20,056,503	22,065
1908 ...	506	844	(l)	528,847	2,108	(h) 110	3,215	21,190,777	27,877
1909 ...	486	968	(l)	611,893	4,395	(h)5,023	3,023	23,350,705	39,815
1910 ...	323	1,482	(l)	725,356	3,359	(h) 386	3,998	24,257,651	62,441
1911 ...	.....	2,120	(l)	845,850	1,537	(h)1,795	2,815	27,412,218	58,071
1912 ...	372	971	(l)	1,056,622	2,890	(h) 778	3,221	31,145,057	56,966
1913 ...	405	.....	(l)	1,129,563	3,409	(h) 681	3,313	34,573,514	60,345

Year.	Copperas.	Cryolite.	Fluorspar.	Graphite.	Gypsum.	Iodine.	Iron.	
							Ore.	Pig.
1901.....	4,125	367	13,436	1,667	40,397	27	2,389,870	150,448
1902.....	4,360	486	14,177	1,691	42,859	24	2,868,068	374,256
1903.....	3,986	349	13,028	1,810	51,874	29	3,343,510	418,072
1904.....	3,514	310	13,540	1,815	55,043	30	3,440,846	225,897
1905.....	4,495	286	15,019	1,971	52,886	27	3,698,563	380,824
1906.....	4,712	(k)	15,493	2,013	63,516	46	3,851,791	479,772
1907.....	6,212	(k)	16,624	2,176	70,737	44	3,904,400	275,170
1908.....	4,393	(k)	14,925	2,469	60,992	51	3,067,737	257,849
1909.....	2,232	(k)	14,534	2,377	63,220	59	2,825,007	471,045
1910.....	2,929	(k)	17,988	3,424	89,590	70	2,952,634	786,854
1911.....	4,151	(k)	23,073	3,822	102,754	73	2,581,698	829,393
1912.....	3,386	(k)	21,145	4,501	108,624	79	2,309,628	1,016,261
1913.....	5,382	(k)	25,523	5,423	132,693	92	2,613,158	782,911

Year.	Lead.					Lime, Chloride of.	Magnesite.	Magnesium Chloride.	Manganese Ore.
	Ore.	Pig and Scrap.	Litharge.	White.	Red.				
1901 ...	891	20,820	4,876	16,966	7,776	32,705	2,485	16,102	5,584
1902 ...	2,024	23,100	4,072	19,070	8,372	29,694	2,955	14,757	4,528
1903 ...	1,270	30,243	5,175	20,765	7,617	28,849	2,812	17,008	11,138
1904 ...	1,312	23,169	5,410	16,638	7,544	30,078	1,917	16,706	5,536
1905 ...	1,496	32,515	4,466	16,478	8,902	30,667	2,552	21,673	4,116
1906 ...	1,915	27,067	2,493	14,022	9,450	29,485	2,843	26,708	2,555
1907 ...	1,296	38,259	4,470	13,651	9,371	24,946	3,264	29,566	3,554
1908 ...	1,189	29,967	5,242	13,733	9,602	23,895	4,021	27,525	2,333
1909 ...	2,556	31,674	4,750	10,583	9,058	27,314	3,702	31,334	4,488
1910 ...	2,382	31,025	4,865	13,595	10,444	24,716	5,399	35,352	4,557
1911 ...	3,746	32,063	5,436	14,962	11,321	27,107	4,496	43,896	9,615
1912 ...	3,273	38,122	6,480	12,750	10,116	32,254	7,132	39,559	7,790
1913 ...	4,458	41,369	6,203	12,402	8,898	36,473	5,857	55,505	9,388

Year.	Mineral Pigments.	Nickel.	Ozokerite.	Petroleum Products. (*f*)		Phosphorus.	Phosphate Rock.
				Illuminating Oil.	Lubricating Oil.		
1901.....	12,671	390	1,700	655	963	149	2,260
1902.....	14,392	689	1,856	824	1,177	260	1,103
1903.....	15,161	700	2,027	701	1,975	286	4,342
1904.....	16,395	1,203	2,447	760	1,763	236	3,222
1905.....	17,603	1,034	2,757	7,286	1,746	228	3,720
1906.....	4,290	954	509	673	9,982	228	5,484
1907.....	4,097	930	692	770	10,552	165	1,494
1908.....	15,675	1,349	921	1,008	10,852	160	1,196
1909.....	18,130	1,606	1,300	588	11,621	168	5,429
1910.....	19,355	1,381	1,642	472	17,141	160	5,044
1911.....	22,426	1,592	1,295	274	18,905	192	10,591
1912.....	27,313	1,677	1,167	244	19,635	219	7,032
1913.....	30,348	1,673	1,999	.....	.....	192	6,885

Year.	Potassium Salts.						Potassium and Potassium-magnesium Sulphate.	Pumice Stone. (*g*)	Pyrite.
	Carbonate	Cyanide. (*f*)	Chloride.	Hydroxide.	Iodide.	Nitrate.			
1901 ...	15,567	2,089	118,959	14,892	145	13,439	37,216	699	23,680
1902 ...	14,041	3,257	106,925	13,804	152	9,734	40,487	691	35,370
1903 ...	13,121	2,017	125,302	13,006	154	9,671	56,455	794	32,611
1904 ...	10,777	3,290	140,765	24,963	174	10,405	64,400	943	30,666
1905 ...	11,963	4,005	156,440	22,246	170	12,140	67,286	939	35,195
1906 ...	12,543	5,049	171,994	21,772	168	11,564	54,557	1,578	35,829
1907 ...	13,314	5,210	173,638	20,254	146	12,668	128,344	2,590	24,183
1908 ...	13,009	4,887	174,345	25,048	127	10,643	181,975	6,055	16,384
1909 ...	13,797	6,283	216,286	27,095	122	12,498	201,393	9,140	11,564
1910 ...	13,099	6,329	266,783	29,094	124	14,728	273,614	7,643	9,871
1911 ...	14,584	6,554	329,751	28,921	133	16,430	392,129	22,075	11,015
1912 ...	12,991	6,718	286,614	26,623	143	14,451	134,079	19,978	27,917
1913 ...	16,271	6,678	393,320	44,113	160	16,058	192,565	4,052	28,214

Year.	Quicksilver.	Salt.	Slag and Slag Wool.	Sodium Salts.					
				Bicarbonate.	Carbonate.	Hydroxide.	Nitrate. (Chile Saltpeter).	Soda, Calcined.	Sulphate and Sulphite.
1901...	27	286,424	27,269	1,086	1,382	4,926	13,481	45,967	45,462
1902...	109	328,324	22,726	954	2,449	5,650	14,737	33,109	56,748
1903...	62	399,184	14,674	1,016	2,982	5,886	17,583	46,086	47,660
1904...	43	347,351	38,587	1,524	3,050	5,084	21,075	43,590	45,506
1905...	48	284,203	28,032	1,881	4,113	5,925	20,531	46,768	54,377
1906...	21	97,878	49,912	2,120	5,860	6,101	22,099	41,598	64,217
1907...	26	92,288	46,680	1,764	2,680	7,462	22,715	36,802	69,231
1908...	26	318,395	74,821	1,713	3,842	7,626	23,549	56,839	78,510
1909...	29	364,107	61,674	1,292	2,968	8,314	28,019	54,493	74,512
1910...	31	370,074	58,832	1,370	5,994	9,295	27,095	56,545	89,208
1911...	36	374,633	88,423	1,598	1,782	10,635	27,937	60,102	89,110
1912...	37	430,137	128,740	1,584	1,057	12,460	27,431	66,760	85,416
1913...	53	432,387	.....	1,869	1,354	13,030	27,507	69,993	83,239

Year.	Sodium and Potassium Salts.		Stassfurt Salts.	Strontium.		Sulphur.	Sulphuric Acid.
	Chromates.	Sulphides.		Carbonate. (n)	Salts.		
1901.....	2,791	2,763	592,347	384	1,022	621	42,853
1902.....	2,656	4,565	499,220	762	1,546	576	47,666
1903.....	2,977	5,845	501,385	819	1,389	1,052	50,109
1904.....	2,272	5,489	631,762	613	1,207	1,418	52,696
1905.....	2,133	6,569	852,454	613	1,386	1,198	48,701
1906.....	2,877	6,730	831,293	1,726	1,578	1,582	52,720
1907.....	3,016	8,103	839,889	1,462	1,671	1,501	49,950
1908.....	4,402	6,536	818,677	1,494	1,822	1,765	60,588
1909.....	4,789	7,596	946,457	2,636	1,832	1,935	63,817
1910.....	4,246	8,679	1,181,208	2,456	1,275	2,727	66,581
1911.....	5,193	7,837	1,154,974	595	.....	1,757	64,888
1912.....	5,167	7,640	.....	1,830	138	1,746	75,962
1913.....	5,667	9,226	.....	1,958	330	3,472	64,968

Year.	Superphosphate.	Tin, Crude.	Zinc.				Zinc White, Zinc Gray and Lithophone.
			Ore.	Spelter and Scrap.	Drawn or Rolled.	Sulphate.	
1900.....	77,118	1,626	34,941	51,899	16,709	382	20,729
1901.....	79,190	1,683	14,002	54,490	16,517	324	24,201
1902.....	77,818	2,271	46,965	70,292	17,015	430	28,400
1903.....	99,672	2,581	40,458	67,057	15,715	264	27,527
1904.....	129,925	2,965	40,488	70,063	17,917	332	26,898
1905.....	115,886	3,259	38,972	67,675	18,982	296	27,877
1906.....	104,713	4,845	42,546	69,142	17,794	426	26,296
1907.....	115,049	4,244	34,863	93,649	21,484	425	30,453
1908.....	125,464	3,707	39,450	75,290	18,661	347	26,372
1909.....	168,988	5,431	51,994	82,225	18,961	342	25,970
1910.....	211,812	7,530	59,440	8,803	26,623	334	36,350
1911.....	221,521	7,582	48,998	81,042	36,093	387	34,419
1912.....	271,349	6,368	51,242	105,328	26,379	.....	44,169
1913.....	282,653	6,437	44,731	109,606	24,965	.....	46,106

(a) From *Statistisches Jahrbuch für das Deutsches Reich.* (b) Includes celestite. (d) Includes precipitated chalk. (f) Includes sodium cyanide. (g) Includes tripoli. (h) Includes nickel ore. (i) Included under chromium ore. (k) Included under bauxite. (l) Included under magnesium chloride. (m) Includes all alkali metals. (n) Includes witherite.

GREECE

The statistics of mineral production in Greece, according to the latest available reports, are summarized in the following table:

MINERAL PRODUCTION OF GREECE (a)
(In metric tons or dollars; 1 drachma = 20 cents)

Year.	Chrome Ore.	Emery.	Gypsum.	Iron Ore.	Iron Ore, Manganiferous.	Lead, Soft.	Lead Ore, Argentiferous.	Lead, Argentiferous.	Lead, Fume.	Lignite.
1900 ..	5,600	6,328	129	279,880	243,920	245	878	16,150	2,045	12,940
1901 ..	4,580	5,691	671	278,640	196,152	(b)	(b)	17,644	5,292	9,726
1902 ..	11,680	4,727	172	364,340	170,040	(b)	430	14,048	1,647	6,500
1903 ..	8,478	5,586	94	531,804	152,740	(b)	(b)	12,361	(b)	8,687
1904 ..	6,530	6,182	117	422,159	108,319	(b)	(b)	15,186	(b)	13,500
1905 ..	8,900	6,972	57	465,622	89,687	(b)	(b)	13,729	(b)	11,757
1906 ..	11,530	7,718	85	680,620	96,382	(b)	(b)	12,308	(b)	11,582
1907 ..	11,730	10,652	105	768,863	92,970	(b)	(b)	13,814	(b)	11,719
1908 ..	4,350	7,471	61	531,368	65,757	(b)	(b)	15,892	(b)	8,786
1909 ..	9,600	8,193	208	475,616	54,926	(b)	(c)	14,948	(b)	3,873
1910 ..	9,450	12,939	243	535,482	50,015	(c)	8,355	16,710	(b)	1,500
1911 ..	12,915	10,544	1,263	496,731	27,482	.....	182,324	14,283	.....	.....
1912 ..	6,468	3,359	127	376,931	12,212	.....	175,463	14,489	.....	.....
1913 ..	6,342	5,560	2,230	310,078	6,323	.....	159,348	18,309	.....	170

Year.	Magnesite.			Manganese Ore.	Puzzolan.	Sea Salt.	Sulphur.	Zinc Ore.	
	Crude.	Bricks.	Calcined.					Blende.	Calamine, Calcined.
1900....	17,277	534	807	8,050	49,426	22,411	891	(b)	18,751
1901....	20,348	500	2,009	14,166	80,169	23,079	3,212	454	17,764
1902....	23,020	935	4,730	14,960	32,514	25,200	1,391	(b)	18,670
1903....	28,415	(b)	(b)	9,340	40,978	26,000	1,266	(b)	12,350
1904....	9,133	(b)	(b)	8,549	44,644	27,000	1,225	(b)	19,913
1905....	37,063	(b)	(b)	8,171	41,900	25,201	1,126	(b)	22,562
1906....	40,584	(b)	(b)	10,040	30,622	25,167	(b)	(b)	26,258
1907....	55,816	(b)	(b)	11,139	39,637	26,966	(b)	(b)	30,346
1908....	63,079	(b)	(b)	10,750	52,312	23,988	(b)	28,739	24,101
1909....	56,797	294	16,609	5,374	46,238	29,448	(b)	41,656	30,159
1910....	18,073	295	19,982	41	31,609	25,978	(b)	(f)5,845	28,898
1911....	86,956	275	27,530	**732**	31,647	26,952	(h)35,956	35,856	30,512
1912....	106,338	496	33,848	**7,719**	19,400	31,400	(h)31,811	39,585	28,912
1913....	98,517	.....	31,815	**556**	24,906	19,215	(h)26,013	30,717	20,646

(a) Statistics up to 1903 communicated by E. Grohmann, Seriphos. Statistics for 1903 and subsequent years from *Statistique du Mouvement Minier de Grèce*. The figures represent sales or shipments. (b) Not reported. (c) No sales, but production of lead ore is reported at 240,013 tons in 1909 and 185,207 tons in 1910. (f) Production in 1910 was 37,108 tons. (h) Pyrite.

INDIA

The official statistics of mineral production in British India are summarized in the subjoined table:

MINERAL PRODUCTION OF INDIA (*a*)

(In metric tons or dollars; £1 = $5)

Year.	Amber.	Coal.	Chromite.	Diamonds *Carats.*	Gold. (*c*)	Graphite.	Iron Ore.	Jade. (*e*) *Cwt.*	Magnesite.
1900...	$515	6,222,591	.....	.....	$9,205,518	1,859	(*d*)57,912	142	(*b*)
1901...	55	6,741,899	.....	.....	9,394,723	2,530	(*d*)58,725	206	(*b*)
1902...	2,160	7,543,272	.....	.....	9,611,985	4,648	(*d*)77,273	174	3,597
1903...	2,070	7,557,400	248	.....	11,203,926	3,448	(*d*)62,337	99	838
1904...	4,190	8,348,561	3,596	286.5	11,513,340	2,955	72,757	130	1,193
1905...	4,725	8,552,422	2,708	172.4	11,760,957	2,361	104,174	106	2,645
1906...	3,545	9,939,782	4,375	305.9	10,852,546	2,642	75,295	116	1,861
1907...	1,925	11,326,254	18,597	268.0	10,348,795	2,472	68,928	2,636	189
1908...	1,820	12,974,588	4,821	140.8	10,597,404	2,919	60,175	3,211	7,655
1909...	1,435	12,060,580	9,398	147.8	10,728,900	3,182	84,791	2,487	749
1910...	1,415	12,240,775	1,765	77.7	10,717,300	4,319	55,499	1,908	5,265
1911...	665	12,715,534	2,865	53.0	10,890,804	4,047	366,212	2,063	3,546
1912...	895	14,946,985	2,936	27.8	11,054,608	*Nil*	580,029	806	15,626
1913...	145	16,478,142	4,908	115.7	11,152,463	*Nil*	.....	3,281	16,468

Year.	Manganese Ore.	Mica.	Petroleum. *Gallons.*	Rubies. *Carats.*	Salt.	Saltpeter (Potassium. Nitrate.)	Tin Ore.
1900....	129,865	1,025	37,729,211	486,630	1,071,877	20,189	94
1901....	122,831	1,505	50,075,117	522,380	1,208,933	17,711	63
1902....	160,311	806	56,607,688	434,475	1,116,797	17,320	91
1903....	174,563	1,002	87,859,069	444,095	1,021,581	18,711	100
1904....	152,601	828	118,491,382	453,060	1,319,535	14,200	63
1905....	250,788	1,172	144,798,444	.....	1,426,066	15,745	68
1906....	579,231	2,458	140,553,122	465,115	1,371,172	16,822	87
1907....	916,770	2,652	152,045,677	491,290	1,120,453	18,664	77
1908....	685,135	2,720	176,646,320	239,770	1,390,153	19,620	96
1909....	652,958	1,672	233,678,087	293,200	1,275,688	20,953	86
1910....	813,721	1,153	214,829,647	294,245	1,720,194	16,140	90
1911....	670,290	1,700	225,792,094	288,213	1,325,882	14,679	97
1912....	637,444	2,196	249,083,518	323,245	1,454,602	14,797	175
1913....	730,016	2,325	277,555,225	278,706	1,320,820	14,333	359

(*a*) Records of the Geological Survey of India. (*b*) Not reported. (*c*) £1 = $4 866. (*d*) Production of iron ore in Bengal only. (*e*) Exports in cwt. of 112 lb.

ITALY

The following tables itemize the statistics of the production and the foreign commerce of mineral and metallurgical products in Italy:

MINERAL PRODUCTION AND REFINED PRODUCTS OF ITALY (a)
(In metric tons or dollars; 5 lire = $1)

Year.	Alum.	Aluminium Sulphate.	Alunite.	Antimony.	Antimony Ore.	Asphalt, Mastic, and Bitumen.	Asphaltic Rock.	Barytes.
1899.....	945	2,330	5,800	581	3,791	41,732	81,987	12,545
1900.....	1,097	2,403	5,200	1,174	7,609	33,127	101,738	14,003
1901.....	1,075	2,260	4,900	1,721	8,818	31,814	104,111	13,245
1902.....	3,995	2,620	8,200	1,574	6,116	33,684	64,245	13,245
1903.....	3,980	2,210	8,100	905	6,927	35,757	89,078	12,420
1904.....	2,490	2,210	8,000	836	5,712	30,817	111,390	12,290
1905.....	2,975	2,740	8,500	327	5,083	26,838	106,586	12,670
1906.....	2,878	2,800	7,500	537	5,704	34,386	130,225	12,020
1907.....	3,175	3,010	7,600	610	7,892	38,568	161,126	15,732
1908.....	2,875	2,100	6,165	345	2,821	34,761	134,163	15,432
1909.....	2,580	2,750	5,636	59	1,077	39,165	111,067	16,240
1910.....	2,510	2,773	6,081	*Nil*	2,194	41,705	162,212	14,420
1911.....	2,725	2,493	6,100	*Nil*	2,441	50,179	188,133	13,620
1912.....	1,299	2,727	6,002	*Nil*	1,878	52,707	181,397	13,420
1913.....	1,009	3,308	5,976	76	1,822	56,750	171,097	12,970

Year.	Borax, Refined.	Boric Acid.		Coal. (c)	Coal (Briquettes).	Coke.	Copper.		
		Crude.	Refined.				Ore.	Ingot, etc.	Sulphate.
1899...	709	2,674	129	388,534	566,000	485,951	94,764	10,236	7,795
1900...	858	2,491	283	479,896	703,740	487,831	95,644	10,405	13,191
1901...	544	2,558	347	425,614	754,800	490,803	107,750	2,639	15,374
1902...	375	2,763	238	414,569	713,430	528,765	101,142	10,230	14,601
1903...	377	2,583	187	346,887	724,993	554,559	114,823	11,217	18,164
1904...	569	2,624	314	362,151	903,610	607,297	157,503	11,873	17,237
1905...	1,007	2,700	749	412,916	842,250	627,984	149,035	16,132	26,212
1906...	1,062	2,561	562	473,293	829,277	672,689	147,137	15,456	34,270
1907...	880	2,305	466	453,137	787,087	717,704	167,619	17,491	45,263
1908...	1,024	2,520	429	480,029	822,699	813,842	106,629	18,280	42,598
1909...	1,110	2,431	578	555,073	924,479	999,381	90,272	20,005	28,551
1910...	912	2,502	695	562,154	918,055	1,160,543	68,369	22,467	36,236
1911...	738	2,648	444	555,137	794,206	363,493	68,136	22,908	44,626
1912...	813	2,309	760	663,812	876,565	437,706	86,001	26,659	52,311
1913...	1,070	2,410	743	701,081	896,091	498,442	89,487	24,625	44,497

Year.	Gold.		Graphite.	Iron and Steel.				
	Ore.	Bullion.		Ore.	Pig.	Bar, Sheet, Pipe, Wire, etc.	Tin Plate.	Steel.
1899.....	11,859	$91,416	9,990	236,549	19,218	197,730	8,000	108,501
1900.....	5,840	52,357	9,720	247,278	23,990	190,518	10,000	115,887
1901.....	890	8,120	10,313	232,299	15,819	180,729	7,550	123,310
1902.....	1,215	10,269	9,210	240,705	30,640	163,055	8,800	108,864
1903.....	5,734	24,667	7,920	374,790	90,744	177,392	11,275	154,134
1904.....	6,746	36,996	9,765	409,460	112,598	181,385	16,655	177,086
1905.....	1,200	7,200	10,572	366,616	181,248	205,915	18,560	244,793
1906.....	6,543	42,720	10,805	384,217	180,940	236,946	16,350	332,924
1907.....	13,475	41,000	10,989	517,952	148,996	248,157	24,423	346,749
1908.....	14,671	48,223	12,914	539,120	158,100	302,509	28,277	437,674
1909.....	2,890	18,230	11,583	505,095	254,904	281,098	35,880	608,795
1910.....	2,147	11,746	12,510	551,259	399,700	311,210	42,670	670,983
1911.....	2,080	16,440	12,621	373,786	302,931	303,223	25,662	697,958
1912.....	2,366	13,271	13,170	582,066	379,989	179,516	28,916	801,907
1913.....	2,047	23,580	11,145	603,116	426,755	142,820	29,185	846,085

Year.	Lead.		Manganese Ore.	Manganiferous Iron Ore.	Marble.	Petroleum. Crude.	Refined Petroleum, Benzene, etc.	Pumice Stone.
	Ore.	Pig.						
1899.....	31,046	20,543	4,356	29,874	313,744	2,242	5,384	7,300
1900.....	35,103	23,763	6,014	26,800	310,336	1,683	6,077	7,000
1901.....	43,449	25,796	2,181	24,290	334,146	2,246	4,211	8,300
1902.....	42,330	26,494	2,477	23,113	363,463	2,633	5,413	8,300
1903.....	42,443	22,126	1,930	4,735	374,975	2,486	4,577	8,300
1904.....	42,846	23,475	2,836	2,836	390,118	3,543	6,388	11,600
1905.....	39,030	19,077	5,384	5,384	389,869	6,122	9,924	11,300
1906.....	40,945	21,268	3,060	20,500	430,202	7,452	10,954	16,366
1907.....	(d)43,037	22,978	3,654	18,874	434,612	8,326	10,556	11,500
1908.....	46,649	26,003	2,750	17,812	425,600	7,088	10,876	15,000
1909.....	37,945	22,133	4,700	25,830	391,295	5,895	11,077	10,000
1910.....	36,840	14,495	4,200	25,700	427,274	7,069	12,149	12,900
1911.....	39,008	16,684	3,515	6,482	497,741	10,390	15,569	16,430
1912.....	41,680	21,450	2,641	*Nil*	522,088	7,479	13,792	17,386
1913.....	44,654	21,674	1,622	*Nil*	509,342	6,572	11,160	14,973

Year.	Pyrite (Cupriferous in Part).	Quicksilver.		Salt.			Silver.	
		Ore.	Metal.	Brine.	Rock.	Sea.	Ore.	Bullion. *Kg.*
1899.....	76,538	29,322	205	11,021	18,721	363,826	540	33,645
1900.....	71,616	33,930	260	10,890	18,331	338,034	584	31,169
1901.....	89,376	38,614	278	10,690	23,054	401,443	511	32,464
1902.....	93,177	44,261	259	10,581	23,677	424,239	421	29,522
1903.....	101,455	55,528	312	10,962	25,911	451,633	405	24,388
1904.....	112,004	60,403	352	11,878	18,638	433,810	143	24,943
1905.....	117,667	63,378	369	12,756	19,669	405,274	170	20,215
1906.....	122,364	80,638	417	13,751	19,007	496,872	48	20,362
1907.....	126,925	76,561	434	19,238	31,540	454,454	62	20,502
1908.....	131,721	82,534	684	15,180	24,033	473,857	53	20,746
1909.....	149,084	97,592	771	15,081	28,026	421,362	44	20,534
1910.....	165,688	87,129	894	16,600	39,197	447,440	32	14,237
1911.....	165,273	97,803	955	17,251	43,763	460,439	24	12,143
1912.....	277,585	88,200	1,000	18,775	39,954	466,220	27	14,363
1913.....	317,334	109,379	1,004	17,727	41,323	585,028	*Nil*	13,094

Year.	Sulphur.			Talc, Ground.	Zinc.	
	Crude (Fused).	Ground.	Refined.		Ore.	Spelter.
1899.....	563,697	161,509	110,213	11,000	150,629	251
1900.....	544,119	167,466	157,957	14,415	139,679	547
1901.....	563,096	171,252	141,431	11,770	135,784	511
1902.....	539,433	125,620	127,483	10,100	131,965	.....
1903.....	553,751	139,376	139,464	6,300	157,521	126
1904.....	527,563	189,266	163,695	6,740	148,365	189
1905.....	568,927	180,676	180,774	6,626	147,834	5
1906.....	499,814	176,476	170,990	7,894	155,751	99
1907.....	426,972	151,338	160,617	8,850	160,517	188
1908.....	445,312	160,693	156,995	9,410	(e)152,254	(b)
1909.....	435,060	132,531	144,579	9,530	(g)130,890	(b)
1910.....	(i)430,366	171,570	169,093	11,580	(g)146,307	(b)
1911.....	414,161	158,977	166,802	14,156	139,719	(b)
1912.....	389,451	164,864	168,514	14,324	149,776	(b)
1913.....	386,310	156,103	151,713	21,350	158,278	(b)

(*a*) From *Rivista del Servizio Minerario.* (*b*) Not reported. (*c*) Includes anthracite, lignite, fossil wood, and bituminous schist. (*d*) Does not include 680 tons lead and zinc ore. (*e*) Includes 560 tons lead-zinc ore. (*g*) Includes 290 and 300 tons lead-zinc ore, 1909 and 1910. (*i*) Besides 21,297 tons ore sold. Natural.

MINERAL IMPORTS OF ITALY (a)

(In metric tons or dollars; 5 lire = $1)

ear.	Anti-mony.	Arsenic. *Kg.*	Asbestos.	Asphal-tum.	Barytes.	Borax and Boric Acid.	Cement and Hydraulic Lime.	Lime.
....	37	900	1,645	1,933	859	122	15,494	18,436
....	49	1,800	2,019	1,450	825	232	14,872	20,731
....	80	1,200	1,536	1,020	1,170	516	13,732	15,216
....	98	4,400	1,691	1,567	1,099	504	15,547	10,063
....	131	3,700	2,174	2,604	1,875	271	15,260	6,891
....	117	3,400	1,806	3,252	1,444	112	15,797	5,556
....	50	5,300	2,171	2,854	1,400	163	18,937	7,714
....	163	3,100	3,110	3,661	1,540	307	29,024	6,156
....	153	2,800	2,548	3,730	1,523	333	28,935	7,210
....	293	4,800	2,285	3,826	2,094	386	25,250	11,120
....	342	5,300	2,051	3,365	1,777	363	22,183	9,007
....	358	5,500	3,892	4,238	2,024	741	24,467	7,942
....	636	4,600	4,080	3,548	1,986	380	23,423	6,809
....	513	2,500	4,750	4,300	1,771	159	19,950	5,501
....	198	3,500	2,710	2,924	1,409	280	15,002	3,810

ar.	Coal.	Copper, Ore.	Copper, Cement.	Copper, Brass and Bronze.	Copper and Iron Sulphates.	Gold. *Kg.*	Graphite.
.....	4,859,556	2,777	1,328	7,334	27,408	326	608
.....	4,947,180	5,290	1,298	9,249	32,127	309	982
.....	4,838,994	11,047	1,987	8,659	32,058	494	102
.....	5,406,069	9,422	2,299	10,865	25,107	479	60
.....	5,546,823	9,459	649	9,588	24,566	1,396	63
.....	5,904,578	8,104	309	15,198	37,298	1,961	52
.....	6,437,539	6,879	486	18,188	30,684	5,768	107
.....	7,673,435	9,363	802	21,458	25,060	4,571	361
.....	8,300,439	18,023	888	28,937	15,939	4,443	267
.....	8,452,320	14,784	344	28,025	25,037	(*d*) 8,367	383
.....	9,303,506	11,303	630	22,391	9,137	(*d*) 8,311	141
.....	9,338,752	7,550	456	30,339	13,599	(*d*)13,188	229
.....	9,595,882	6,607	277	38,650	37,929	(*d*)12,712	246
.....	10,057,228	6,253	578	43,729	36,602	(*d*)10,545	403
.....	10,834,008	737	352	39,552	30,472	(*d*) 9,940	567
.....	9,758,877	850	*Nil*	28,062	21,939	(*d*)10,281	162

ar.	Iron.		Iron and Steel Scrap.	Lead.		Lead Oxide and Carbon-ate.	Mineral Paints.
	Ore.	Pig.		Ore. (*c*)	Metal and Alloys in Pigs.		
.....	20,799	191,613	245,616	7,476	3,990	662	958
.....	19,205	160,686	197,415	9,134	3,248	557	958
.....	4,054	159,972	148,305	9,063	2,926	815	865
.....	4,314	155,143	198,914	1,680	7,563	846	670
.....	5,937	126,756	206,036	689	5,398	768	859
.....	4,390	149,130	246,359	2,187	4,541	871	940
.....	4,745	136,077	276,311	465	6,764	686	974
.....	6,452	168,985	344,977	4,526	10,958	984	964
.....	22,046	231,042	362,567	4,342	9,231	953	1,119
.....	31,090	254,239	326,119	5,620	11,742	1,474	2,616
.....	28,150	246,730	416,354	3,003	10,011	1,132	1,713
.....	17,673	204,854	386,604	1,426	14,674	1,225	1,775
.....	50,554	234,770	392,703	6,042	20,187	1,077	1,756
.....	18,606	267,355	343,728	12,391	15,627	917	1,962
.....	8,026	221,688	326,231	9,552	11,494	682	2,410
.....	4,592	219,995	254,858	15,736	9,820	533	2,053

Year.	Nickel Alloys and Manufactures.	Petroleum.	Phosphate Rock.	Potash, Ammonia, and Caustic Soda.	Potassium Sulphate.	Quicksilver.	Silver. *Kg.*	Slag, Metalliferous.
1900.....	232	73,089	140,281	14,077	1,670	49	2,678	32,254
1901.....	476	69,298	142,108	14,693	1,411	36	4,391	7,312
1902.....	561	68,781	159,341	17,617	1,566	57	8,768	5,634
1903.....	525	68,220	172,328	17,528	1,353	28	12,541	8,849
1904.....	652	69,233	217,162	14,846	1,663	25	15,885	3,521
1905.....	574	66,493	240,144	17,752	1,804	57	20,697	72,785
1906.....	717	64,541	307,762	16,718	1,534	12	20,410	88,118
1907.....	725	72,715	384,896	15,225	3,866	11	21,829	5,378
1908.....	1,079	82,373	531,921	14,962	4,891	10	(*d*)83,434	1,122
1909.....	540	88,929	478,199	15,547	5,333	2.2	(*d*)47,234	878
1910.....	1,311	84,748	422,714	16,983	7,753	2.5	(*d*)55,516	3,153
1911.....	1,584	119,245	479,042	16,312	9,493	2.0	(*d*)52,576	95
1912.....	1,742	113,231	466,144	17,816	13,466	1.5	(*d*)79,763	184
1913.....	1,200	115,374	529,776	17,407	9,454	0.3	(*d*)87,856	2,560
1914.....	1,111	116,276	513,998	16,382	3,708	*Nil*	102,090(*d*)	700

Year.	Sodium Salts.		Sod. and Pot. Nitrates, Refined.	Tin.		Zinc.			
	Carbonate.	Nitrate (Crude).		Block.	Mnfrs.	Ore.	Oxide.	Spelter and Old.	Mnfrs.
1899....	22,654	22,385	671	1,240	96	(*b*)	804	3,498	3,221
1900....	23,215	27,706	511	1,643	56	85	1,034	3,627	3,543
1901....	21,956	40,498	315	1,858	91	23	813	3,991	4,079
1902....	26,133	24 483	314	2,114	110	131	904	3,805	4,167
1903....	24,753	43,480	638	2,288	130	46	1,416	4,551	4,461
1904....	27,747	32,283	613	2,170	150	362	1,124	5,202	4,168
1905....	29,066	46,517	689	2,304	103	14	1,246	5,997	4,701
1906....	31,170	32,508	395	3,361	167	2,042	1,920	6,835	4,421
1907....	35,538	41,457	668	2,771	183	11	1,962	8,152	5,407
1908....	38,268	60,784	428	2,602	187	7	2,026	9,339	5,112
1909....	38,252	43,658	532	2,555	191	13	1,571	9,222	4,572
1910....	45,174	61,192	1,083	2,760	238	18	2,001	8,971	5,416
1911....	45,596	59,561	417	2,524	211	428	2,100	10,742	5,892
1912....	49,284	54,634	529	2,627	157	*Nil*	2,550	11,955	5,833
1913....	52,332	67,418	574	2,973	144	5	2,983	12,448	6,071
1914....	48,115	59,850	310	2,744	110	*Nil*	2,348	10,518	4,002

MINERAL EXPORTS OF ITALY (*a*)

(In metric tons or dollars; 5 lire = $1)

Year.	Antimony.	Asbestos.	Asphaltum.	Barytes.	Borax and Boric Acid.	Cement and Hydraulic Lime.	Lime.	Coal.
1900.....	467	261	24,287	40	2,114	6,860	3,428	23,926
1901.....	765	302	21,856	32	2,190	8,463	4,215	25,594
1902.....	359	144	20,884	91	1,847	7,930	3,802	33,374
1903.....	314	222	24,303	36	901	6,325	4,089	29,219
1904.....	107	163	14,880	70	1,122	7,810	5,007	35,149
1905.....	132	236	23,740	162	2,255	8,445	4,194	38,555
1906.....	208	205	27,176	147	2,777	6,774	3,118	31,686
1907.....	115	142	26,036	152	1,330	4,477	3,224	40,769
1908.....	10	193	24,158	724	1,005	5,439	2,533	46,774
1909.....	8	527	21,978	125	1,704	7,534	3,525	51,343
1910.....	2	485	26,125	150	1,536	7,131	5,764	48,144
1911.....	*Nil*	517	28,455	353	1,347	10,742	9,440	40,800
1912.....	11	571	13,158	381	1,661	55,091	6,736	26,298
1913.....	*Nil*	672	6,645	234	1,373	55,908	5,161	192,002
1914.....	51	509	6,367	210	1,195	40,880	5,161	52,620

Year.	Copper, Ore.	Copper and Iron Sulphate.	Gold. *Kg.*	Graphite.	Iron.		
					Ore.	Pig.	Scrap.
1899	1,148	20	1,162	8,114	234,515	378	.....
1900	1,179	60	2,763	7,820	170,286	329	.....
1901	9	20	2,955	7,169	121,592	311	.....
1902	11	39	733	7,098	209,070	395	.....
1903	15	44	1,291	7,068	98,319	810	.....
1904	43	29	1,494	7,433	2,577	229	.....
1905	77	249	1,731	6,811	11,358	1,395	.....
1906	189	102	1,476	4,904	1,833	254	.....
1907	179	835	802	7,474	26,000	121	.....
1908	188	721	7,588	7,009	35,653	176	1,676
1909	233	1,211	15,452	8,125	46	209	1,480
1910	969	741	16,643	7,647	9,892	327	2,450
1911	130	157	14,144	7,633	22,851	290	3,390
1912	267	1,445	13,993	7,785	12,313	51	5,662
1913	285	609	16,440	8,329	9,660	555	6,895
1914	432	1,856	6,724	8,589	8,943	69	4,636

Year.	Lead.			Mineral Paints.	Phosphate Rock.	Quicksilver.	Salt.	Silver. *Kg.*
	Ore.	Lead Alloys, in Pigs.	Oxide and Carbonate.					
1899	3,129	2,497	389	2,784	(*b*)	223	114,050	32,432
1900	3,741	5,018	367	2,977	1,726	259	112,900	25,310
1901	3,977	4,463	410	2,913	1,290	301	114,210	42,325
1902	3,354	5,650	404	2,953	894	215	145,190	20,427
1903	5,041	2,911	426	3,305	2,942	222	144,910	9,486
1904	5,524	1,954	347	3,231	2,812	266	130,940	24,165
1905	4,311	976	310	3,632	3,519	243	116,040	25,947
1906	8,356	2,005	315	4,502	1,652	278	126,199	18,262
1907	3,213	1,548	240	4,602	4,560	350	99,191	18,164
1908	2,041	1,243	219	3,446	2,271	565	85,489	(*d*)28,716
1909	1,037	782	211	4,310	2,979	714	103,895	(*d*)87,653
1910	4,122	933	197	3,945	3,627	781	122,404	(*d*)22,403
1911	15,791	637	196	4,182	5,427	1,037	119,173	(*d*)28,434
1912	17,062	4,122	75	4,417	1,285	993	155,543	(*d*)28,275
1913	16,950	577	314	4,166	4,171	993	161,118	179,322
1914	27,516	189	687	4,232	8,569	760	124,860	14,451

Year.	Slag.	Sodium Salts.			Sulphur.	Tin.		Zinc.		
		Carbonate	Nitrate (Crude).	Sod. and Pot. Nitrates, Refined.		Block.	Manufactures	Ore.	Oxide.	Spelter and Scrap.
1899	4,898	438	136	124	424,018	69	176	140,107	123	227
1900	4,222	486	58	129	479,139	147	153	111,870	102	359
1901	3,261	377	116	59	414,018	202	187	103,020	140	349
1902	3,615	446	346	259	439,242	236	174	114,894	122	338
1903	4,929	482	781	492	461,289	173	180	116,449	116	591
1904	4,458	376	363	230	437,067	171	151	126,393	483	263
1905	9,844	214	424	159	381,128	285	107	117,810	173	434
1906	8,990	253	80	133	336,339	303	81	144,244	687	639
1907	10,934	200	138	102	297,378	434	117	142,271	727	1,182
1908	12,122	583	37	57	330,093	180	173	122,456	395	984
1909	17,163	517	464	163	329,233	85	126	123,936	212	983
1910	10,488	321	98	45	344,513	164	245	127,315	957	845
1911	8,274	180	168	15	398,592	166	319	133,471	1,577	616
1912	19,563	243	27	7	376,387	83	359	152,840	2,165	1,222
1913	8,251	337	50	10	351,339	152	394	144,644	1,313	1,566
1914	7,822	123	179	12	260,332	179	313	89,776	1,219	1,234

(*a*) From *Statistica del Commercio speciale di Importazione e di Esportazione.* (*b*) Not reported. (*c*) Includes argentiferous lead ore. (*d*) Includes coin, bullion, sheets, and leaf.

JAPAN

The total mineral production of the Japanese Empire, according to the latest available returns, is shown in the following table, in metric tons, unless otherwise specified. Figures in full-faced type are either provisional figures or estimates.

MINERAL PRODUCTION OF JAPAN (a)

Year.	Antimony.		Arsenic. *Kg.*	Coal.	Copper.	Gold. *Kg.*	Graphite	Pig. Iron.	Lead.
	Ore.	Metal.							
1899....	712	229	5,077	6,668,608	19,421	1,675	53	23,066	1,963
1900....	81	349	4,669	7,370,667	24,317	2,124	94	24,841	1,878
1901....	118	429	10,312	8,884,812	27,392	2,475	88	29,449	1,803
1902....	88	528	12,188	9,588,910	29,034	2,975	97	32,130	1,644
1903....	153	434	6,000	10,088,845	33,245	3,140	114	33,870	1,728
1904....	104	321	4,000	10,723,796	33,187	2,765	216	38,143	1,803
1905....	96	190	8,333	11,955,946	35,944	3,048	209	53,210	2,272
1906....	97	627	5,250	13,468,529	36,963	2,873	177	57,373	4,305
1907....	(b)	248	7,491	13,764,731	40,183	2,938	103	44,447	3,079
1908....	(b)	198	19,838	14,767,638	41,399	3,598	177	42,007	2,910
1909(d)	10	157	8,061	14,810,412	45,117	3,932	121	46,627	3,337
1910(d)	8	120	11,463	15,433,621	48,545	4,368	145	58,043	3,845
1911....	.....	97	5,760	17,632,710	53,401	4,690	114	63,986	4,125
1912....	.....	80	.....	19,515,285	62,939	5,233	149	56,265	3,764
1913....	.....	.....	.....	21,664,764	66,537	4,666	.....	57,513	3,779
1914....	.....	.....	.....	**19,686,630**	**63,374**	**6,736**	.....	.....	.....

Year.	Manganese Ore.	Petroleum. *Gallons.*	Phosphates.	Pyrite.	Quicksilver. *Kg.*	Salt. *Hectoliters.*	Silver. *Kg.*	Sulphur.	Tin.
1899....	11,336	18,844,034	(b)	8,376	.....	10,483,082	56,161	10,237	18.5
1900....	15,831	30,470,068	(b)	16,166	270	11,890,361	58,799	14,439	12.3
1901....	16,270	39,056,820	(b)	17,589	750	12,463,771	54,739	16,548	14.1
1902....	10,844	34,850,129	196	18,580	1,418	11,042,192	57,635	18,287	18.6
1903....	5,616	50,724,174	191	16,149	206	6,574,890	58,704	22,914	19.0
1904....	4,324	51,573,754	13	24,886	*Nil.*	7,019,650	61,339	25,587	25.0
1905....	14,017	47,132,800	1,519	25,569	349	(b)	82,886	24,652	26.0
1906....	54,339	60,005,957	3,037	36,038	336	(b)	76,247	27,589	77.0
1907....	20,586	60,110,558	1,721	56,166	456	(f)636,168	95,600	33,329	31.8
1908(d) .	11,130	65,165,860	740	33,867	804	(f)659,202	123,180	33,149	25.7
1909(d) .	8,708	65,789,858	3,781	27,066	335	(f)696,049	127,917	36,317	22.8
1910....	11,120	63,843,601	1,042	78,418	407	(f)696,474	141,613	43,155	23.
1911....	9,787	72,839,260	2,271	73,879	1,021	(g)567,715	138,287	50,274	24.8
1912....	12,060	67,557,322	7,847	74,929	27	.....	152,385	55,005	35.6
1913....	.....	**84,869,794**	19,047	114,589	.....	.....	146,180	59,481	379.0
1914....	.....	**123,322,080**	.....	.....	.....	.....	**144,565**	**68,306**	.....

(a) From *Résumé Statistique de l'Empire du Japon*, Tokio. (b) Not reported. (d)From reports of the Japanese Department of Agriculture and Commerce. (f) Metric tons including Taiwan, fiscal years. (g) Metric tons; from *Résumé Statistique de l'Empire du Japan.*

MEXICO

Owing to the incompleteness of the Mexican statistics of production, we are unable to give any satisfactory table. Exports may, however, be taken as indicating the condition of the mining industry. We owe the statistics for 1908, 1909, and 1910, together with a complete revision of this table, to the courtesy of Don Miguel M. Irigoyen, chief of the Section of Statistics, Secretaria de Hacienda y Credito Publico.

MINERAL EXPORTS OF MEXICO (*a*)
(In metric tons or Mexican dollars)

Year.	Antimony.		Coal.	Copper.		Gold.				
	Metal.	Ore.		Ore.	Ingot.	Ore.	Bullion.	Specie.	Cyanide.	Sulphide.
1898...	.....	5,932	118,553	13,146	10,362	$1,037,202	$6,493,735	$367,704	$294,730	$64,061
1899...	.....	10,382	113,192	223	25,293	335,849	7,017,286	183,474	115,961	266,782
1900...	.....	2,313	38,676	408	27,970	306,392	7,435,864	192,456	128,675	177,193
1901...	.....	5,103	17,281	5,576	33,818	284,722	8,324,681	210,431	178,803	81,744
1902...	1,218	1,280	3,406	6,101	63,609	303,979	9,079,371	129,899	78,295	40,658
1903 (*c*)	2,304	7,302	1,840	10,912	51,716	264,503	9,693,692	54,636	85,465	124,020
1904...	1,694	81	125	48,365	57,338	537,290	10,867,272	172,532	79,129	176,090
1905...	1,978	57	497	92,540	56,634	1,513,344	29,636,117	106,470	397,814	138,033
1906...	2,418	178	91	73,193	46,767	5,369,173	21,072,014	37,746	337,294	180,348
1907...	4,615	681	1,532	115,245	51,519	3,033,090	19,653,362	5,023,404	417,162	497,893
1908...	4,046	36	719	70,900	26,214	2,746,289	30,101,546	42,389	144,959	334,944
1909...	4,115	31	235	136,031	32,580	2,346,279	40,725,976	23,678	85,110	250,741
1910...	3,730	6	120	129,568	54,061	2,526,444	46,189,613	37,723	46,803	168,162
1911...	4,131	121	101	109,627	60,493	1,945,660	48,113,427	8,153,293	38,031	141,640
1912...	3,491	15	50,777	103,129	60,439	1,121,333	42,686,667	1,479,292	43,481	119,357
1913...	2,340	(*b*)	40	19,500	29,438	785,531	32,918,172	470,758	54,417	172,188

Year.	Graphite.	Gypsum.	Lead.		Silver.					
			Ore.	Base Bullion.	Ore.	Bullion.	Specie.	Sulphide.	Cyanide.	Slag.
1898...	1,365	1,650	(*b*)	60,918	$11,048,358	$37,137,599	$16,588,789	$1,663,501	$257,342	$46,488
1899...	2,305	1,050	1	67,441	10,766,099	37,585,911	5,580,834	1,929,085	76,942	4,819
1900...	2,561	1,600	468	74,944	12,495,524	41,468,745	22,679,655	1,893,646	67,607	87,880
1901...	762	800	(*b*)	79,097	9,615,939	36,348,374	12,038,158	2,141,685	259,282	93,543
1902...	1,434	(*b*)	118	107,366	4,108,088	45,796,576	17,753,526	1,978,919	108,344	132,093
1903 (*c*)	1,404	(*b*)	11	100,532	11,781,048	48,276,797	16,167,673	1,642,627	135,561	289,900
1904...	970	(*b*)	1	95,010	11,000,869	45,430,020	7,251,132	1,392,356	171,452	202,594
1905...	970	27	1	101,196	8,505,834	63,564,789	20,335,297	736,228	438,094	29,012
1906...	3,915	(*b*)	(*b*)	73,699	9,619,763	63,057,152	42,390,357	595,112	434,885	(*b*)
1907...	3,202	(*b*)	11	76,158	11,396,844	68,187,169	23,848,571	785,116	483,638	(*b*)
1908...	1,076	(*b*)	26	127,010	11,230,372	63,298,659	60,405	791,698	68,849	(*b*)
1909...	1,704	(*b*)	1	118,186	8,057,189	66,789,716	91,006	557,520	78,688	(*b*)
1910...	2,332	1	355	120,662	6,793,896	70,272,894	72,891	208,300	52,053	(*b*)
1911...	2,974	(*b*)	397	124,605	6,766,644	78,515,378	8,901	235,410	159,170	*Nil*
1912...	2,865	(*b*)	59	109,717	5,769,575	82,047,500	8,645	(*d*)	347,277	*Nil*
1913...	1,057	(*b*)	1,386	55,530	2,108,805	63,232,843	2,585,701	423,625	418,522	(*b*)

(*a*) From the *Estadistica Fiscal*. The figures for the calendar years were arrived at by combining those of the successive semesters of the different fiscal years. (*b*) Not reported. (*c*) Figures for 1904 are from *Anuario Estadistico de la República Mexicana* for 1904. (*d*) 11 metric tons.

NORWAY

The official statistics of mineral production, imports and exports are summarized in the following tables:

MINERAL PRODUCTION OF NORWAY (a)

(In metric tons or dollars; 1 Krone = 27 cents)

Year.	Apatite. (b)	Chrome Ore.	Copper.		Feldspar.	Gold.	Iron.		
			Ore.	Ingot.			Ore.	Pig and Cast.	Bars and Steel.
1901	738	85	40,726	1,073	18,323	$2,700	42,252	261	376
1902	2,295	22	40,499	1,347	19,591	36,990	53,675	527	461
1903	1,795	*Nil.*	35,417	1,382	18,590	8,370	53,475	509	442
1904	1,456	154	36,891	1,342	20,835	*Nil.*	45,328	350	395
1905	2,522	*Nil.*	37,045	1,153	22,508	*Nil.*	46,582	474	253
1906	3,482	*Nil.*	32,203	1,333	23,896	5,400	109,259	257	317
1907	1,830	107	39,887	1,517	32,970	*Nil.*	140,804	*Nil.*	283
1908	1,771	*Nil.*	33,688	1,806	34,437	*Nil.*	119,656	.....	.....
1909	1,364	*Nil.*	42,612	1,594	36,439	8,000	40,389	.....	.....
1910	703	.....	46,308	1,814	39,507	5,000	102,447	.....	.....
1911	897	.....	34,705	1,650	34,864	.....	220,524	316	.....
1912	1,168	115	60,018	2,130	39,844	.....	116,392	291,700	.....
1913	757	.....	70,349	2,741	40,842	2,200	78,936	465,750	346

Year.	Molybdenite.	Nickel.		Pyrite, Iron, and Copper.	Rutile.	Silver.		Zinc Ore. (c)
		Ore.	Metal.			Ore and Native Silver.	Metal. *Kg.*	
1901	.....	2,018	13	101,894	55	519	5,680	90
1902	20	4,040	40	121,247	*Nil.*	471	6,220	30
1903	31	5,670	60	129,939	25	481	7,269	335
1904	30	5,352	75	133,603	25	1,297	8,064	42
1905	46	5,477	73	162,012	35	1,570	7,100	4,241
1906	1,026	6,081	77	197,886	55	1,565	6,370	3,308
1907	30	5,781	81	236,038	55	1,756	6,700	400
1908	35	5,190	81	269,129	83	2,262	7,470	2,435
1909	30	5,770	62	282,606	.....	2,729	7,780	983
1910	.....	19,639	69.8	329,642	116	.....	.....	2,219
1911	.....	27,743	172	369,055	76	2,892	7,635	2,240
1912	21	30,697	390	464,326	100	4,027	8,400	40
1913	12	49,990	690	441,291	77	5,411	9,400	897

(a) *Tabeller vedkommende Norges Bergverkdsdrift*, and *Statistisk Aarbok for Kongeriket Norge*.
(b) Exports which represent production. (c) Includes lead ore.

MINERAL IMPORTS OF NORWAY (a)

(In metric tons)

Year.	Borax. *Kg.*	Cement and Hydraulic Lime.	Coke, Coal, and Cinders. *Hectoliters.*	Copper and Brass.		Iron and Steel.	
				Plates and Bars.	Wares.	Pig.	Bars, Hoops, etc. Wrought Iron.
1902	(c)	18,984	19,338,615	1,118	(c)	18,969	26,685
1903	(c)	17,906	20,086,974	899	309	20,652	21,977
1904	54,953	12,845	21,049,128	688	866	18,891	24,094
1905	(c)	13,797	20,973,608	882	1,146	20,828	27,740
1906	63,000	11,676	21,478,000	906	783	20,197	26,015
1907	79,810	16,647	24,274,260	(f) 954	1,107	23,345	32,764
1908	87,255	44,991	(e)2,073,907	(f)1,013	1,157	26,106	31,849
1909	79,786	57,768	(e)2,095,611	(f) 869	1,095	23,167	31,215
1910	105,453	20,100	(e)2,159,717	(f)1,118	1,406	28,034	34,623
1911	100,493	17,892	(e)2,187,246	(f)1,229	1,780	26,569	36,172
1912	103,923	27,960	(e)2,474,253	(f)1,567	2,116	29,908	44,756
1913	107,633	31,989	(e)2,482,424	(f)1,769	2,035	30,682	49,442
1914	.....	40,762	(e)2,749,250	3,471	2,026	32,199	44,848

Year.	Iron and Steel *Continued.*						Lead in Pigs and Sheets.
	Anchors, Cables, and Chains.	Rails.	Nails, Spikes, and Screws.	Steel.	Sheets and Plates.	Other Manufactures.	
1902	2,103	15,316	2,205	1,754	36,288	22,069	(c)
1903	1,807	4,631	1,261	1,958	42,098	18,855	311
1904	2,109	5,814	1,071	1,610	42,013	5,462	498
1905	2,224	6,566	1,222	1,436	42,203	44,414	448
1906	2,585	8,086	1,012	2,018	48,969	45,959	727
1907	2,653	6,989	991	1,592	47,758	48,965	887
1908	2,535	12,180	1,032	1,628	49,569	52,594	529
1909	1,750	9,051	1,049	1,911	46,195	55,198	536
1910	2,131	5,512	852	3,203	56,898	60,282	838
1911	2,327	15,312	1,129	3,908	65,847	72,170	939
1912	2,591	12,276	1,313	4,239	84,525	86,552	1,142
1913	2,479	15.291	.....	3,197	76,158	86,411	1,054
1914	2,651	21,834	.....	2,739	73,006	98,928	1,079

Year.	Lead-white and Zinc Oxide.	Petroleum and Paraffin.	Potash.	Salt.	Saltpeter.	Soda.	Sulphur. (b)	Tin in Blocks, etc.	Zinc in Bars, Plates, etc.
1902	(c)	(c)	(c)	141,415	315	(c)	(c)	(c)	1,104
1903	(c)	58,822	457	143,110	245	4,200	8,829	106	1,015
1904	1,898	50,543	477	153,699	321	3,197	12,181	176	940
1905	1,309	43,860	393	137,800	1,048	3,704	10,240	134	967
1906	1,149	41,546	396	167,300	776	4,334	11,465	261	2,791
1907	1,245	44,231	588	163,458	1,004	5,819	11,412	332	3,549
1908	1,201	64,680	504	177,349	935	7,850	12,281	323	1,418
1909	1,304	63,042	475	164,195	572	8,357	10,293	280	1,336
1910	1,277	63,976	536	182,288	546	9,270	10,279	358	5,891
1911	1,465	71,496	524	192,354	786	9,566	8,782	353	9,173
1912	1,864	80,023	541	214,817	418	15,877	13,911	439	9,636
1913	2,502	79,253	572	214,987	522	16,255	15,411	333	13,560
1914	2,288	89,692	907	201,255	141	20,275	10,448	696	17,487

MINERAL EXPORTS OF NORWAY (a)
(In metric tons)

Year.	Apatite.	Copper.			Feldspar.	Iodine. *Kg.*	Iron.
		Ore.	Ingot.	Scrap.			Ore.
1902	2,295	4,848	1,913	(c)	(d)19,611	.....	48,775
1903	1,795	3,448	1,930	888	(d)18,640	11,417	41,575
1904	1,456	2,673	1,124	785	20,835	9,414	45,434
1905	2,522	3,393	958	968	20,696	12,000	60,558
1906	3,482	84	875	964	19,669	13,248	81,398
1907	1,830	1,581	1,033	1,644	29,399	13,780	132,593
1908	1,771	156	1,260	385	29,896	11,097	110,425
1909	1,365	3,245	1,335	543	33,692	13,620	38,933
1910	703	241	1,377	583	39,507	13,114	88,715
1911	500	924	1,091	575	34,864	16,982	180,932
1912	.....	423	1,551	366	39,844	11,642	404,990
1913	.....	74	2,644	167	40,843	12,149	568,763
1914	.....	0.1	2,345	676	27,703	2,320	456,925

Year.	Iron (*Continued*).				Nickel Ore.	Pyrite.	Zinc.
	Pig and Scrap.	Bars and Hoops.	Nails and Spikes.	Steel.			
1902	7,359	166	6,431	240	1	105,980	.....
1903	6,350	10	6,504	200	*Nil.*	118,148	.....
1904	10,152	13	7,477	167	30	116,550	.....
1905	9,920	34	8,725	88	220	147,155	.....
1906	7,362	8	6,786	21	*Nil.*	164,119	.....
1907	4,652	7	5,879	31	11	187,983	.....
1908	6,787	2	4,839	17	*Nil.*	218,851	.....
1909	11,429	24	5,187	11	3	216,767	.....
1910	13,455	5	6,878	34	.....	343,073	.....
1911	12,569	40	5,692	271	(g)385	343,850	.....
1912	16,889	.....	5,326	296	(g)594	424,121	.....
1913	26,917	.....	3,972	150	.....	460,912	10,536
1914	14,498	.....	3,804	1,274	(g)646	400,996	16,428

(a) From *Tabeller vedkommende Norges Bergvaerksdrift* and *Tabeller vedkommende Norges Handel.* (b) Includes flowers of sulphur. (c) Returns not available. (d) Includes a small quantity of fluorspar. (f) Includes a quantity of sheet aluminium. (g) Metallic nickel.

PORTUGAL

The subjoined table reports the mineral production of Portugal:

MINERAL PRODUCTION OF PORTUGAL (a)

(In metric tons)

Year.	Antimony Ore.	Arsenic Ore.	Coal (Anthracite). (c)	Copper.			
				Copper-Iron Pyrite. (e)	Other Ores.	Cement.	Matte.
.....	38	1,031	24,066	402,870	(b)	2,948	(b)
.....	(b)	527	16,000	443,397	(b)	2,061	(b)
.....	68	736	11,000	413,714	655	2,205	(b)
.....	83	698	8,063	376,177	527	2,448	(b)
.....	31	1,370	12,805	383,581	297	(b)	(b)
.....	84	1,562	11,449	352,479	210	2,148	(b)
.....	481	1,322	6,762	350,746	196	3,634	(b)
.....	383	1,538	8,824	241,771	2,478	2,942	298
.....	76	1,655	4,614	81,417	15,455	3,041	564
.....	6	1,420	6,274	12,337	1,321	3,037	309
.....	25	974	8,149	19,161	230	3,768	230
.....	.....	887	10,610	15,287	517	3,979	283
.....	100	1,006	15,626	120,148	1,309	4,028	.....
.....	19	925	25,087	13,550	.....	4,177	.....

Year.	Gold. Kg.	Iron Ore.	Lead Ore (Galena).	Manganese Ore.	Sulphur Ore.	Tin Ore and Metal.	Tungsten Ore.
.....	2.6	19,803	3,620	1,970	(e)	31	49
.....	2.0	21,599	445	904	(e)	31	90
.....	2.0	19,914	1,651	(b)	(e)	24	234
.....	1.3	15,200	830	30	(e)	(b)	228
.....	*Nil.*	12,488	291	(b)	(e)	51	290
.....	*Nil.*	3,200	50	(b)	(e)	20	358
.....	*Nil.*	(b)	511	22	(e)	22	570
.....	10.5	(b)	510	1,374	123,393	35	226
.....	57.0	(b)	481	(b)	24,522	28	106
.....	25.0	(b)	736	(b)	272,398	18	673
.....	4.1	3,360	919	(b)	293,745	9	948
.....	3.6	19,541	1,185	6	267,486	86	903
.....	3.5	35,210	495	6	481,295	173	1,227
.....	1.0	49,182	1,046	(b)	377,533	254	1,039

(a) From reports specially furnished *The Mineral Industry* by the Chief of the Department of Mines of the Ministerio das Obras Publicas, except for 1904 to 1906, inclusive, and 1913, which are from official Government reports. The mineral production of the country is identical with exports, except in the case of coal. (b) Not reported. (c) Consumed in the country. (e) Previous to 1907 the figures for "Sulphur Ore" (largely pyrite) were included under "Copper-Iron Pyrite."

RHODESIA

The statistics of the mineral production of Rhodesia for the last 12 years are given in the accompanying table.

MINERAL AND METALLURGICAL PRODUCTION OF RHODESIA (a)

Year.	Gold. *Oz.*	Value.	Silver. *Oz.*	Lead. *Tons.* (b)	Coal. *Tons.* (b)	Year.	Gold. *Oz.*	Value.	Silver. *Oz.*	Lead. *Tons.* (b)	Coal. *Tons.* (b)
1903...	231,872	$4,022,756	20,715	.....	.....	1909..	623,388	$12,985,430	262,133	965	170,888
1904...	267,737	4,711,016	70,146	455	59,678	1910..	609,956	12,657,791	217,633	749	180,092
1905...	407,048	7,046,692	89,278	570	97,191	1911..	628,521	12,991,500	187,641	639	212,229
1906...	551,894	9,647,581	110,575	652	103,803	1912..	642,807	13,174,058	176,532	587	216,146
1907..	612,052	10,589,385	147,324	756	115,073	1913..	689,954	14,261,343	142,390	327	243,225
1908..	606,962	12,276,394	283,424	1,069	164,114	1914..	854,480	17,423,087	150,793	168	391,394

(a) From report of Colonel Seely, Under-Secretary of State for the colonies. (b) Short tons.

RUSSIA

'he mineral and metallurgical production of Russia, according to the ; statistics available to MINERAL INDUSTRY, is given in the subjoined les.

MINERAL AND METALLURGICAL PRODUCTION OF RUSSIA (a)

(In metric tons; 1 metric ton = 61.05 poods)

Asbestos.	Chrome Ore.	Coal.	Copper.	Gold. (b)	Pig Iron.	Lead.	Manganese Ore.
1,665	15,466	12,307,463	7,290	$22,195,208	2,241,293	241.2	329,276
2,693	19,146	13,974,376	7,533	22,396,315	2,708,752	321.8	659,302
3,845	18,233	16,156,055	8,258	22,369,864	2,933,786	220.7	802,236
4,398	22,169	16,526,652	8,467	22,763,967	2,866,779	156.0	522,395
4,508	19,656	16,465,852	8,817	22,258,343	2,598,086	225.3	536,519
5,264	16,421	17,868,515	9,232	24,147,222	2,487,783	106.3	414,334
7,502	26,575	19,608,631	9,835	24,627,537	2,972,115	90.3	430,090
5,896	27,051	18,727,766	8,515	20,521,587	2,628,101	700.2	508,635
9,197	16,969	21,593,158	9,296	20,020,862	2,694,895	906.8	1,015,686
9,398	(g) 26,357	25,741,321	15,930	26,518,253	3,041,570	520.0	(g) 1,003,528
10,911	(g) 10,950	(g) 25,903,560	17,118	33,143,810	2,818,450	522.5	362,303
(h) 13,129	22,213	24,532,349	19,656	31,889,956	2,889,353	.....	574,938
(h) 10,936	1,362	(f) 23,105,628	(f) 22,619	(f) 35,566,045	(f) 3,042,046	.....	668,050
17,071	1,238	28,007,239	(f) 25,097	(f) 34,550,609	3,593,000	.....	(i) 636,180
18,138	21,277	30,641,163	33,513	28,852,881	3,726,000	.....	903,226
18,594	.....	32,206,000	34,282	22,199,000	3,801,273	.....	1,130,000

Petroleum.	Phosphate Rock.	Platinum. Kg.	Pyrite.	Quicksilver.	Salt.	Silver. Kg.	Sulphur.	Zinc.
8,009,828	1,867	6,016	24,570	362	1,505,602	5,143	1,018	5,664
8,517,608	16,863	5,962	23,250	362	1,679,726	4,419	451	6,326
9,844,390	25,663	5,089	23,154	141	1,968,007	2,293	1,587	5,963
10,925,471	21,276	6,371	30,732	363	1,705,924	1,088	2,489	6,104
10,445,536	13,709	6,135	26,465	416	1,847,021	1,200	1,800	8,264
9,759,214	14,635	6,009	22,780	362	1,658,938	1,152	281	9,894
10,058,968	20,282	5,016	31,667	332	1,908,275	726	16	10,612
7,505,637	20,585	5,250	30,689	318	1,844,678	2,965	16	7,911
8,167,934	18,970	5,776	20,660	210	1,730,934	430	39	9,602
9,098,931	(g) 15,457	5,903	18,316	(g) 132	1,873,171	7,843	(d) 57	10,409
8,732,301	(g) 14,976	4,883	56,345	147	1,879,717	9,595	(d) 85	9,960
8,961,507	(h) 21,326	5,120	(f) 46,078	.....	2,259,690	(h) 15,415	.....	7,644
8,952,793	(h) 24,883	5,471	(f) 55,980	.....	2,047,980	(h) 14,841	.....	(f) 8,631
9,152,315	(h) 25,503	(f) 5,432	113,054	.....	2,013,765	15,512	.....	(f) 9,652
9,249,600	.....	5,523	123,990	.....	.....	.....	.....	.....
9,474,876	.....	5,287	.....	.....	.....	.....	.....	.....

) From official sources. (b) The value of gold is taken at $20.67 per ounce. (d) Includes ide ore. (f) Statistics of Association of Russian Manufacturers and Traders. (g) St. Petersburg tific Committee. (h) The Russian Year Book, Dr. Kennard, London. (i) Exports. (j) *Mineral irces of U. S.*

SOUTH AMERICA

The following tables itemize the statistics of the production and the foreign commerce, or both, of mineral and metallurgical products of South American countries so far as available. No statistics later than those given in the tables have been published. Figures in full-faced type are either provisional figures or estimates.

MINERAL AND METAL PRODUCTION OF BOLIVIA (*a*)

(In metric tons)

Year.	Antimony Ore.	Bismuth.		Cobalt Ore.	Copper. (*c*)	Gold. (*b*)	Silver. (*d*)	Tin Ore.	Tungsten Ore.
		Metal.	Ore.						
1907....	2,279	249	153.379	.....	3,469	$3,551	3,696	27,668	(*e*)500
1908....	734	259	160.305	.....	3,027	21,617	156.5	29,938	170
1909....	.....	89	236.762	.....	3,097	.....	155.4	35,566	170
1910....	.....	97	311.060	.....	3,212	.....	143	38,548	207
1911....	311.7	.....	1,206.689	.....	2,950	22,313	128.0	37,073	297
1912....	91.3	(*g*)478	.....	.....	4,707	23,038	123.9	38,614	472
1913....	62.0	.....	422.0	.....	4,020	175,000	81.3	44,597	283

(*a*) From a British Consular report and Revista de Aduanas. (*b*) Reduced to U. S. currency. (*c*) Includes ingots, precipitate, matte and concentrate. (*d*) Includes ingots, ore, and sulphide. (*e*) U. S. Geol. Surv. (*g*) Metal and metal content of ore.

MINERAL EXPORTS OF BRAZIL (*a*)

(In metric tons or dollars) (*d*)

Year.	Agate.	Carbonado. *Carats*	Copper Ore. *Carats.*	Diamonds. *Carats.*	Gold.	Manganese Ore.	Mica and Talc.	Monazite.	Platinum. *Grams.*	Precious Stones. (*b*)	Rock Crystal.
1905..	83	113,157	658	142,459	$647,581	224,377	1.0	4,437	72,000	88,463	23
1906..	121	319,743	1,484	340,137	771,611	121,331	$6,123	4,351	*Nil*	141,395	37
1907..	53	363,200	(*c*)	110,457	1,976,000	236,778	8,176	4,438	*Nil*	33,335	37
1908(*e*)	79	126,380	(*c*)	97,090	2,187,950	166,122	5,540	4,965	*Nil*	109,150	36
1909(*e*)	.....	177,572	(*c*)	58,862	2,252,900	240,774	.....	6,462	*Nil*	56,338	.....
1910(*e*)	34	13,848	(*c*)	14,366	1,954,674	253,953	.....	5,437	*Nil*	745	.....
1911(*e*)	112	63,400	1	103,567	2,850,370	173,941	9	371	*Nil*	135,220	24
1912(*e*)	103	47,998	.....	139,175	2,676,950	154,870	11.5	3,398	*Nil*	74,597	45
1913..	.....	.....	.....	.....	2,692,154	183,630	.....	600	.....	21,022	.....

(*a*) As reported by the *Brazilian Review*. (*b*) Other than carbonado and diamonds. (*c*) Statistics not available. (*d*) The par exchange value of the *Mil Reis* in 1907 was $0.546 U.S. gold. Common exchange value was in 1902, $4.155; in 1903, $4.134; in 1904, $4.146; in 1905, $3.153; in 1906, $3.103, and in 1907, $3.301. (*e*) Reported by U. S. Consul at Rio de Janeiro.

MINERAL PRODUCTION OF CHILE (a)
(In metric tons)

Year.	Borax.	Coal.	Cobalt Ore.	Copper.	Gold. Kg.	Guano.	Iodine.	Salt.	Silver. Kg.	Sodium Nitrate.	Sulphur.
1900..	86,892 (b)	(c)	(d)	25,715	1,975	(f)	302	9,879	73,071	1,460,100	2,472
1901..		(c)	(d)	30,155	1,100	(f)	269	10,099	70,237	1,273,800	2,516
1902..		(c)	(d)	27,066	1,286	(f)	242	9,532	57,418	1,400,408	2,636
1903..	16,879	827,112	290	29,923	994	11,134	387	16,264	28,552	1,444,920	3,560
1904..	16,733	751,628	125	31,025	1,135	2,669	461	17,674	28,501	1,487,598	3,594
1905..	19,612	793,927	28	29,126	1,055	19,380	564	12,108	16,315	1,669,806	3,470
1906..	28,996	932,488	0.19	25,829	1,135	4,709	331	17,116	12,211	1,822,144	4,598
1907..	28,374	832,612	.....	28,863	1,907	7,518	4,202	18,982	18,736	1,846,036	2,905
1908..	35,039	939,836	.....	42,097	1,189	871	330	16,257	43,569	1,970,974	2,705
1909..	32,218	898,971	.....	42,726	1,268	10,692	474	20,463	35,907	2,110,961	4,508
1910..	35,192	1,074,174	.....	38,232	1,088	12,683	581	23,361	34,958	2,465,415	3,823
1911..	45,558	1,188,053	.....	36,420	437	17,841	437	23,720	27,675	2,521,023	4,451
1912..	43,356	1,334,407	.....	41,647	1,101	18,266	458	17,045	30,178	2,585,850	4,431
1913..	.....	.....	.....	42,264	.....	.....	437	.....	.....	.....	.....

(a) From *Estadistica Minera de Chile.* (b) The combined output of the years 1894 to1902 , inclusive. (c) The combined output of Chile up to the end of 1902 is estimated at 20,650,000 tons. (d) The combined output of Chile up to the end of 1902 is estimated at 5941 tons. (f) The combined output of Chile up to the end of 1902 is estimated at 163,704 tons, valued at 5,041.560 pesos ($1,840,-169).

MINERAL AND METAL PRODUCTION OF PERU (a)
(In metric tons)

Year.	Bismuth.	Borate.	Coal. (b)	Copper.	Gold. Kg.	Lead.	Nickel. Kg.	Petroleum.	Quicksilver. Kg.	Silver. Kg.	Salt.	Sulphur.
1907...	48	2,451	185,565	20,681	777.6	5,525	.....	100,184	1,500	207,810	21,592	1,880
1908...	9	2,870	311,122	19,854	977.0	2,633	.....	125,948	1,822	195,404	21,899	.....
1909...	30	2,715	321,502	26,068	554.0	2,093	.....	188,128	350	207,656	22,715	.....
1910...	24	2,351	307,320	27,347	708.0	1,866	.....	167,712	350	252,565	17,594	.....
1911...	24	1,923	324,000	27,735	741.2	2,208	.....	195,276	560	289,383	24,867	.....
1912...	51	1,674	278,927	26,970	1,435.0	4,050	.....	233,600	400	324,352	23,292	.....
1913...	25	2,001	273,945	27,776	1,435.0	3,927	.....	276,147	460	299,132	24,433	.....
1914...	.....	.....	.....	.....	670.0	.....	.....	.....	.....	.....	.....	.....

(a) Reported by the Cuerpo de Ingenieros de Minas del Peru, in its *Boletin.* (b) Includes asphaltum and bituminous schist.

SPAIN

The following tables record the mineral and metal production of Spain as reported by official authorities:

MINERAL PRODUCTION OF SPAIN (a)
(In metric tons)

Year.	Alumi-nous Earths.	Anti-mony Ore.	Arsenic.	Asphal-tum.	Asphalt, Rock.	Barytes.	Cement, Hydrau-lic.	Coal.	
								Anthracite.	Bituminous.
1900...	420	30	150	2,331	4,193	833	185,811	68,427	2,514,545
1901...	305	10	120	4,182	3,956	1,067	189,909	85,266	2,566,591
1902...	337	67	*Nil.*	6,034	6,301	642	201,856	109,298	2,614,010
1903...	381	42	1,088	4,675	6,277	507	245,294	108,959	2,587,652
1904...	925	245	400	3,463	3,761	453	286,737	163,275	2,903,771
1905...	221	77	1,140	5,805	5,725	290	296,605	159,517	2,912,466
1906...	386	180	1,114	6,229	7,794	330	299,294	113,747	3,095,043
1907...	1,209	205	1,500	8,643	8,219	314	329,926	164,498	3,531,337
1908...	60	124	2,004	9,231	12,373	334	343,001	188,463	3,696,653
1909...	35	(*b*)	506	6,582	5,284	422	472,909	198,302	3,662,573
1910(*f*)	400	15	444	8,473	7,795	476	484,161	211,958	3,600,056
1911...	461	100	331	3,495	6,500	635	486,085	209,227	3,454,394
1912(*h*).	.....	500	.....	5,387	.....	1,096	.....	226,663	3,625,666
1913(*i*).	.....	.....	.....	5,582	.....	3,049	.....	232,517	3,783,214

Year.	Coal (*Continued*).		Coke.	Copper Ore.		Copper.			Fluor-spar.
	Lignitic.	Briquets.		Argentiferous.	Pyritic.	Fine.	Matte.	Precipitate.	
1900...	91,133	341,156	381,000	2,006	2,714,714	5	18,159	29,652	4
1901...	95,867	338,684	455,586	(*b*)	2,672,365	79	15,634	28,433	(*b*)
1902...	84,242	331,957	404,503	878	2,617,776	(*b*)	.....	36,045	93
1903...	104,232	339,120	433,780	3,056	2,796,733	(*b*)	.....	27,448	4,000
1904...	100,773	307,630	432,726	(*b*)	2,624,512	(*b*)	8,117	29,494	(*b*)
1905...	168,994	290,830	448,073	(*b*)	2,621,054	(*b*)	8,243	17,988	(*b*)
1906...	189,048	311,328	435,808	(*b*)	2,888,778	(*b*)	9,068	19,200	70
1907...	191,001	355,718	476,360	(*b*)	3,182,645	(*b*)	9,886	20,887	270
1908...	223,160	296,216	477,059	(*b*)	2,985,779	(*b*)	205	19,599	253
1909...	265,019	(*b*)	500,909	(*b*)	2,955,254	(*b*)	2,077	16,641	246
1910(*f*)	245,518	474,891	521,078	(*b*)	3,231,418	85	2,684	14,056	180
1911...	252,051	478,143	516,342	(*b*)	3,284,184	(*g*)76	1,910	12,353	499
1912(*h*).	283,480	465,106	489,558	.....	3,366,165	.....	1,861	.....	265
1913(*i*).	276,791	486,228	595,677		2,265,642	.....	3,049	.....	351

Year.	Iron Ore.		Iron and Steel.			Kaolin (China Clay).	Lead (Argentiferous).	
	Argentif-erous.	Non-argen-tiferous.	Pig.	Wrought Iron.	Iron and Steel, Worked.		Ore.	Metal.
1900...	26,348	8,675,749	91,126	54,307	144,355	3,794	182,016	74,341
1901...	27,726	7,906,517	135,600	47,085	121,023	2,220	207,188	73,895
1902...	24,361	7,904,555	330,747	.....	163,564	3,412	227,645	74,370
1903...	90,996	8,304,153	380,284	.....	199,642	2,578	179,858	56,687
1904...	122,109	7,964,748	283,819	50,858	186,705	1,700	177,104	57,956
1905...	152,027	9,007,245	305,462	11,366	223,545	720	160,381	56,361
1906...	126,445	9,448,533	315,309	6,035	274,280	610	158,425	53,856
1907...	(*b*)	9,896,178	355,240	14,767	310,125	640	165,289	51,430
1908...	(*b*)	9,271,592	403,554	21,807	262,843	1,370	165,382	53,741
1909...	3,813	8,786,021	428,622	24,187	218,410	570	161,496	43,552
1910(*f*)	46,161	8,666,795	373,322	59,133	201,798	1,496	150,592	38,548
1911...	.....	8,773,691	408,667	11,166	264,930	4,469	156,569	40,379
1912(*h*).	1,588	9,133,007	366,136	.....	.....	4,920	93,850	49,212
1913(*i*).	.....	9,861,668	350,433	.....	.....	5,263	23,600	15,704

Year.	Lead (Non-argentiferous).		Manganese Ore.	Mineral Paints (Ocher).	Phosphate Rock.	Pyrites (Iron).	Pyrites (Arsenical).	Quicksilver.	
	Ore.	Metal.						Ore.	Metal.
1900 ...	131,437	98,189	112,897	58	4,170	34,638	515	30,216	1,095
1901 ...	174,376	95,399	60,325	164	4,220	33,953	1,328	23,367	754
1902 ...	100,403	103,190	46,069	(b)	1,150	145,173	5,648	26,037	1,425
1903 ...	108,660	118,422	26,194	(b)	1,124	155,739	7,996	30,370	968
1904 ...	93,230	127,906	18,732	(b)	3,305	161,841	3,510	27,185	1,130
1905 ...	105,113	129,332	26,020	(b)	1,370	179,079	4,790	26,485	853
1906 ...	105,095	131,614	62,822	164	1,300	189,243	2,434	28,965	1,568
1907 ...	103,632	135,066	41,504	114	3,547	225,830	3,423	28,789	1,212
1908 ...	126,667	134,321	16,745	400	4,483	263,451	5,533	42,210	1,068
1909(f) .	137,050	136,441	7,827	418	1,387	258,931	3,235	37,398	1,393
1910 ...	216,738	151,975	8,607	759	2,840	294,184	1,461	22,714	1,114
1911 ...	165,843	149,540	5,607	622	3,520	344,879	1,056	19,940	1,494
1912(h)	190,162	183,400	17,400	.....	3,292	421,070	.....	21,889	1,256
1913(i)	279,078	183,125	21,594	.....	3,548	926,913	.....	19,960	1,246

Year.	Salt.	Silver.		Soapstone.	Sulphur.		Tin Ore, Dressed.	Topaz. Kg.	Tungsten Ore.	Zinc.		
		Ore.	Metal. Kg.		Crude Rock.	Refined.				Ore.	Spelter.	Sheets.
1900..	450,041	742	140,457	8,109	64,364	750	47	95	1,958	86,158	2,855	2,756
1901..	345,063	391	94,977	4,880	49,856	610	115	310	6	119,708	2,573	2,781
1902..	426,434	175	96,975	542	15,442	450	12,762	Nil.	11	127,618	5,569	(b)
1903..	427,394	231	112,978	3,725	38,573	1,608	330	90	Nil.	154,126	5,134	(b)
1904..	543,658	303	117,418	5,165	40,389	605	229	....	60	156,329	5,887	2,913
1905..	493,451	540	123,607	4,364	38,153	610	209	....	375	160,561	6,184	2,936
1906..	541,978	470	126,424	3,609	28,965	700	86	171	430	170,384	6,209	2,639
1907..	605,895	702	127,435	13,875	27,054	3,612	315	266	386	191,853	6,144	2,485
1908..	822,677	441	129,881	4,730	13,872	2,988	838	(b)	226	156,233	6,357	2,693
1909(f	800,703	388	143,403	5,583	21,750	3,429	(c) 1,555	(b)	129	163,522	9,625	(b)
1910..	678,057	217	129,157	4,665	30,113	3,834	35	149	153	156,113	8,557	2,722
1911..	654,767	858	110,082	5,647	40,662	6,580	34	.....	96	162,140	2,904	3,429
1912(h	23,292	668	143,400	.....	42,344	4,592	5,079	.....	169	175,311	8,451	.....
1913(i	26,238	405	266,606	.....	62,653	7,499	6,626	.....	235	174,831	7,935	.....

(a) Figures are from *Estadistica Minera de España*, except for 1896 and 1898, which were from the official *Reports of the Junta Superior Facultativa de Minas* Madrid. (b) Not reported. (c) Undressed tin ore. (f) *Revista Minera*, June 24, 1911. (g) Blister copper 18,295 tons· copper sulphate 15,893 tons. (h) *Revista Minera*, Apr. 24, 1914. (i) *Revista Minera*, Feb. 24, 1915.

SWEDEN

The official statistics of mineral production, imports and exports, are summarized in the following tables:

MINERAL PRODUCTION OF SWEDEN (a)
(In metric tons)

Year.	Alum.	Coal.	Copper.			Feldspar.	Graphite.	Gold. Kg.
			Ore.	Ingot.	Sulphate.			
1901.....	121	271,509	23,660	137	1,224	13,502	56	62.7
1902.....	132	304,733	30,095	178	1,257	17,960	63	94.3
1903.....	140	320,390	36,687	776	1,171	19,392	25	50.6
1904.....	125	320,984	36,834	533	1,248	18,021	55	60.9
1905.....	139	322,384	39,255	1,385	1,029	19,224	40	55.0
1906.....	167	296,980	19,655	1,209	562	21,014	37	20.3
1907.....	131	305,338	21,957	1,577	782	20,244	33	28.1
1908.....	138	305,206	21,371	2,808	731	17,494	66	20.3
1909.....	132	246,808	9,562	2,375	628	15,772	26	14.1
1910.....	182	302,786	3,638	3,111	20	21,591	49	2.0
1911.....	159	311,809	1,623	3,221	320	36,235	65	11.0
1912.....	145	360,291	3,059	3,957	870	34,305	79	30.5
1913.....	144	363,965	5,458	6,891	428	37,878	88	25.0

Year	Iron and Steel.					Steel.		
	Ore.	Pig.	Blooms.	Bars, Rods, Sheets, etc.	Iron Sulphate.	Bessemer.	Basic.	Crucible.
1901....	2,793,566	528,375	164,850	269,507	140	77,231	190,877	1,088
1902....	2,896,208	538,113	186,076	(b)	127	84,014	201,311	1,091
1903....	3,677,520	506,825	192,342	325,200	62	84,229	232,878	1,105
1904....	4,083,945	528,525	189,246	324,676	148	78,577	252,832	1,162
1905....	4,364,833	539,437	182,640	356,898	144	78,204	288,675	1,319
1906....	4,501,656	604,789	178,298	381,118	170	84,633	311,435	1,457
1907....	4,478,917	615,778	174,405	403,994	159	77,036	341,893	1,287
1908....	4,712,494	567,821	152,256	363,408	277	81,054	355,394	1,169
1909....	3,885,046	444,764	120,669	292,478	182	63,351	248,757	927
1910....	5,549,987	603,929	151,713	408,191	236	97,503	372,451	2,215
1911....	6,150,718	634,392	146,722	408,159	156	93,853	372 705	4,309
1912....	6,699,226	699,816	.....	.....	.....	107,254	307,637	.....
1913....	7,475,571	**735,000**	.....	.....	320	**115,700**	467,100	.....

Year.	Lead.	Manganese Ore.	Pyrites.	Silver-Lead Ore.	Silver. *Kg.*	Sulphur.	Zinc Ore.
1901.....	988	2,271	*Nil.*	11,366	1,557	(b)	61,044
1902.....	843	2,850	*Nil.*	9,378	1,365	74	48,630
1903.....	678	2,244	7,793	9,792	1,005	(b)	48,783
1904.....	589	2,297	15,957	8,187	651	35	62,927
1905.....	576	1,992	20,762	8,397	606	0	57,634
1906.....	753	2,680	21.827	1,938	938	0	56,885
1907.....	813	4,334	27,113	1,987	929	0	52,552
1908.....	277	4,616	29,569	2,058	630	0	50,884
1909.....	166	5,212	16,104	1,721	512	0	40,077
1910.....	355	5,752	25,445	2,700	30	0	43,760
1911.....	1,134	5,377	30,096	2,999	1,289	0	49,453
1912.....	1,073	5,101	31,835	2,877	962	.....	51,242
1913.....	1,235	4,001	34,319	3,222	1,037	.....	50,752

(a) From *Bidrag till Sveriges Officiela Statistik Bergshandteringen.* (b) Not reported.

MINERAL IMPORTS OF SWEDEN (*a*)
(In metric tons or dollars; 1 krone = 27 cents)

Year.	Asbestos. (*c*)	Asphalt.	Barytes.	Borax.	Boric Acid.	Bromine and Bromides. *Kg.*	Cement.	Chalk, White, Unground. *Hectoliters.*	Coal.
1900....	763	5,676	411	194	66	6,084	1,941	12,059	3,033,885
1901....	178	4,524	295	253	68	6,602	2,868	13,569	2,793,309
1902....	213	5,779	.....	242	71	7,278	9,822	11,583	2,911,286
1903....	217	5,957	.....	240	71	7,419	11,145	41,868	3,192,990
1904....	356	6,243	.....	299	77	10,128	10,526	10,115	3,367,826
1905....	140	4,760	264	294	82	18,788	10,999	13,305	3,297,485
1906....	287	7,134	559	321	79	9,908	13,136	10,777	3,718,884
1907....	672	8,213	610	490	85	6,784	17,801	(*g*) 860	4,146,785
1908....	505	6,368	514	347	71	11,499	6,158	(*g*) 419	4,427,507
1909....	383	7,922	529	365	76	10,280	12,944	(*g*) 512	4,084,055
1910....	671	7,406	625	379	92	10,913	15,438	(*g*) 473	4,180,250
1911....	1,011	6,803	607	381	76	16,819	24,830	(*g*) 605	3,964,870
1912....	635	7,645	644	434	199	9,319	17,438	(*g*) 422	4,293,719
1913....	1,094	6,809	610	.....	.....	.....	12,120	(*g*) 2,337	4,878,854

Year.	Copper, also Alloys of Copper.	Emery.	Graphite.	Gypsum.	Iron, Crude.	Lead.	Litharge.	Phosphorus. *Kg.*	Platinum. *Kg.*
1900....	4,745	136	213	6,794	82,957	2,067	148	67,557	59
1901....	5,153	169	180	6,589	66,131	1,991	165	70,672	172
1902....	6,890	147	(*b*)	6,754	43,828	2,509	172	68,441	130
1903....	6,109	132	(*b*)	8,795	49,411	2,644	237	112,659	116
1904....	7,367	221	(*b*)	8,868	90,102	2,849	213	47,421	84
1905....	6,481	271	(*b*)	11,270	87,843	2,823	205	69,526	105
1906....	8,899	284	(*b*)	13,496	108,193	3,457	255	79,048	133
1907....	(*c*) 14,213	336	375	15,037	115,186	3,384	210	77,936	109
1908....	(*c*) 12,392	308	540	11,644	109,841	3,964	248	107,301	117
1909....	(*c*) 11,000	428	443	14,212	99,519	3,222	217	88,241	72
1910....	(*c*) 13,297	438	398	15,816	117,180	3,453	267	99,145	77
1911....	14,014	459	398	14,505	114,859	2,901	270	77,837	103
1912....	7,470	490	513	10,467	140,145	1,204	316	88,411	12
1913....	.....	667	576	13,284	102,744	.....	.....	.....	.....

Year.	Potassium.				Quicksilver. *Kg.*	Salt.		Silver.	
	Chloride.	Cyanide. *Kg.*	Hydrate.	Carbonate.		Crude.	Refined.	Bullion and Mfrs. *Kg.*	Specie.
1900.....	364	2,221	1,915	1,257	3,629	70,302	3,098	11,559	$ 62,315
1901.....	260	2,658	1,435	1,266	5,958	79,038	3,072	7,476	78,416
1902.....	222	2,950	1,720	1,238	4,866	82,439	3,037	4,853	74,826
1903.....	245	3,294	2,034	1,150	5,043	88,139	3,419	11,259	90,366
1904.....	214	3,237	2,234	1,184	5,768	84,237	4,615	19,034	86,891
1905.....	1,296	3,437	2,251	1,133	4,609	87,677	3,889	11,067	82,620
1906.....	1,986	4,106	2,486	1,082	5,535	88,341	3,700	15,253	93,990
1907.....	1,840	4,150	2,484	1,269	8,930	(*h*) 835,190	18,821	26,334	52,074
1908.....	2,190	3,563	2,835	1,209	7,299	(*h*) 903,633	24,394	20,149	93,669
1909.....	1,809	3,808	2,627	1,312	6,077	(*h*) 766,195	24,143	17,315	154,265
1910.....	2,335	4,272	2,767	1,346	7,079	(*h*) 766,512	22,425	21,162	75,604
1911.....	1,288	4,993	3,737	1,268	4,164	(*h*) 736,935	26,026	15,175	134,407
1912.....	228	7,545	(*i*) 3,262	1,380	5,110	1,050	22,009	21,220	164,781
1913.....	.....	.....	.....	.....	.....	.....	.....	.....	.....

Year.	Sodium.				Sulphur.	Sulphuric Acid.	Tin.		
	Carbonate.	Hydrate.	Nitrate. (d)	Sulphate. (e)			Salts. *Kg.*	Block.	Ins.
1901....	13,669	800	17,614	15,494	20,715	1,950	2,334	541	2,900
1902....	.....	1,623	15,553	18,924	23,002	1,887	1,652	644	3,285
1903....	.....	1,426	20,616	16,120	24,577	2,620	1,467	655	3,311
1904....	11,898	2,112	19,776	17,596	18,248	2,001	1,460	719	3,705
1905....	13,592	1,489	23,183	17,115	18,631	3,424	1,722	597	3,780
1906....	14,974	1,478	27,174	19,948	22,745	2,535	1,102	819	4,454
1907....	14,970	1,628	26,181	21,486	25,456	2,628	6,117	891	5,407
1908....	14,149	1,256	27,631	18,717	30,806	3,073	2,817	808	4,626
1909....	13,490	1,119	28,849	20,226	26,836	1,955	1,357	794	5,264
1910....	15,594	1,260	32,315	22,429	38,530	2,707	1,161	764	5,843
1911....	15,777	2,501	31,324	27,482	34,622	861	915	866	5,951
1912....	18,255	.....	35,107	26,540	38,471	593	73,045	1,032	4,817
1913....	.....	.....	.....	.....	.....	.....	.....	.....	.....

MINERAL EXPORTS OF SWEDEN (a)
(In metric tons or dollars; 1 krone = 27 cents)

Year.	Alum.	Ammonium Sulphate.	Antimony, Crude. *Kg.*	Asbestos. *Kg.*	Cement.	Coal (Anthracite).	Copper.		Graphite
							Ore.	Copper and Alloys.	
1899 ...	26	2	2,600	2,812	31,101	762	315	1,230	17
1900 ...	24	2	4,600	2,436	42,564	1,108	448	2,012	18
1901 ...	56	156	1,800	2,179	17,794	716	602	1,243	19
1902 ...	20	174	4,090	1,864	19,499	866	845	1,516	5
1903 ...	22	*Nil.*	3,473	15,357	21,319	509	1,555	1,858	9
1904 ...	9	219	3,810	16,339	27,509	605	749	1,396	(b)
1905 ...	12	445	3,147	2,386	38,504	425	2,137	2,654	(b)
1906 ...	11	30	4,584	1,510	45,960	1,352	1,841	2,662	(b)
1907 ...	7	*Nil.*	4,485	2,167	18,053	2,925	882	2,762	8
1908 ...	9	202	4,188	1,612	34,164	1,293	1,114	3,299	18
1909 ...	5	331	6,536	1,093	33,197	771	723	3,264	7
1910 ...	11	704	4,555	1,242	73,351	776	878	2,580	7
1911 ...	2	253	7,320	760	108,653	1,045	1,114	2,500	12
1912 ...	15	42	9,151	564	127,142	684	1,577	4,273	9
1913 ...	6	254	6,803	1,066	137,074	419	1,709	3,495	45

Year.	Gypsum and Mfrs.	Iron and Steel.		Lead and Mfrs.	Peat.	Phosphorus. *Kg.*	Potassium Chloride.
		Ore.	Unwrought.				
1899.....	8	1,628,011	320,742	818	1,979	1,890	335
1900.....	10	1,619,902	304,175	1,209	3,843	879	931
1901.....	55	1,761,257	268,143	1,028	3,064	1,254	708
1902.....	117	1,729,000	(f) 73,403	546	3,620	1,290	1,114
1903.....	119	2,828,000	(f) 70,788	333	3,217	309	790
1904.....	162	3,065,522	(f) 88,124	275	4,212	1,994	1,266
1905.....	156	3,316,626	(f)120,987	512	5,157	34,388	1,499
1906.....	6	3,661,218	(f)112,719	531	6,531	700	(b)
1907.....	16	3,521,717	201,643	519	6,524	(b)	(b)
1908.....	37	3,654,268	159,095	496	5,559	400	1,363
1909.....	21	3,204,522	161,757	319	9,999	1,305	1,400
1910.....	41	4,434,805	213,861	557	9,754	265	1,383
1911.....	13	5,086,898	226,044	1,181	10,371	595	1,564
1912.....	2	5,520,653	213,619	1,003	7,276	600	1,653
1913.....	1	6,413,644	216,013	745	7,135	900	1,423

Year.	Salt, Refined. *Kg.*	Silver Bullion. *Kg.*	Soda (Carbonate).	Sulphur.	Tin.		Zinc.	
					Block and Scrap.	Mfrs. *Kg.*	Ore.	Crude and Mfrs.
1899....	110	367	227	68	8.8	1,033	45,635	157
1900....	407	296	238	20	21.5	1,521	40,879	157
1901....	1,556	179	237	12	20.4	8,110	41,248	101
1902....	1,945	110	621	147	25.5	1,603	43,813	63
1903....	*Nil.*	484	10	217	43.3	3,893	45,389	351
1904....	1,883	115	45	4	45.6	3,479	44,259	332
1905....	*Nil.*	10	403	4	33.9	654	51,765	295
1906....	8,652	77	463	12	51.0	353	45,380	410
1907....	4,452	160	39	1	67.9	2,518	41,236	529
1908....	14,300	136	114	7	53.9	274	38,543	908
1909....	6,422	437	27	5	42.5	276	38,865	1,200
1910....	1,326	814	31	6	51.1	356	40,405	1,278
1911....	3,450	1,090	40	7	66.0	152	41,854	2,158
1912....	1,668	2,021	3	75	110.0	698	41,985	3,136
1913....	6,916	4,300	2	239	87.0	2,640	46,696	6,533

(*a*) From *Bidrag till Sveriges Officiella Statistik* and *Sveriges Utförsel och Införsel*. (*b*) Not reported. Includes crude and manufactures. (*d*) Includes a small quantity of potassium nitrate. (*e*) Includes sodium bisulphate. (*f*) Includes only crude or ballast iron. (*g*) Metric tons. (*h*) Hectoliters. (*i*) Includes sodium hydroxide.

UNITED KINGDOM

The statistics of the mineral production, imports and exports, according to official reports, are given in the subjoined tables. Figures given in full-faced type are either provisional figures or estimates.

MINERAL AND METALLURGICAL PRODUCTION OF THE UNITED KINGDOM (a)
(In metric tons)

Year.	Alum Shale.	Arsenious Acid.	Arsenical Pyrites.	Barium Minerals.	Bauxite.	Chalk.	Clay. (e)	Coal.
1902....	5,755	2,165	842	23,986	9,192	4,466,004	15,549,002	230,728,562
1903....	3,337	916	58	24,659	6,226	4,541,494	16,460,526	234,019,521
1904....	6,636	992	44	26,748	8,839	4,509,768	16,210,734	236,130,373
1905....	7,245	1,552	651	29,528	7,417	4,608,153	15,376,910	239,906,999
1906....	9,605	1,625	650	36,319	6,760	4,825,299	12,459,213	255,067,822
1907....	10,063	1,523	1,800	42,648	7,658	4,855,857	15,065,141	272,097,858
1908....	5,459	2,007	3,270	39,572	11,904	4,329,983	14,638,710	265,726,332
1909....	9,266	2,926	182	42,436	9,652	4,508,136	14,293,598	268,007,890
1910....	6,781	2,187	958	45,384	4,208	4,705,766	(h)14,316,469	268,677,183
1911....	10,685	2,178	1,189	44,826	6,103	.....	14,057,090	276,255,764
1912....	.....	2,228	1,806	43,453	5,882	4,962,408	.....	264,749,661
1913....	8,887	1,716	36	48,792	6,153	4,939,095	14,090,818	292,047,544
1914....	.....	1,722	.....	46,675	8,420	.....	.....	270,070,414

Year.	Copper.		Fluorspar.	Gold.		Gravel and Sand.	Gypsum.	Bog Ore (Ireland). (c)
	Ore and Precipitate.	Fine.		Ore.	Bullion. *Kg.*			
1902.....	6,210	490	6,388	30,432	130.0	2,100,829	228,264	4,983
1903.....	6,977	545	12,102	29,057	171.0	2,281,689	223,426	4,156
1904.....	5,552	501	18,450	23,574	610.7	2,275,426	237,749	4,616
1905.....	7,267	727	40,079	16,237	169.0	2,277,486	259,596	3,256
1906.....	7,882	(b)	42,521	17,662	(b)	2,404,857	228,627	5,513
1907.....	6,867	677	50,257	13,186	59.4	2,438,798	239,285	6,391
1908.....	5,528	588	35,257	7,237	28.5	2,228,245	231,980	4,364
1909.....	3,777	442	43,165	5,627	37.6	2,199,583	242,832	2,719
1910.....	4,245	456	62,607	6,252	75.5	2,235,160	259,661	2,603
1911.....	3,314	398	56,117	2,796	13.2	2,311,694	281,125	2,743
1912.....	1,942	.....	29,154	173	(b)	.....	247,724	(b)
1913.....	2,108	.....	54,557	4	.....	2,449,305	242,341	.....
1914.....	2,561	.....	.....	55	.....	.....	223,764	.....

Year.	Iron.		Lead.		Manganese Ore.	Mineral Paints.	Oil Shale.	Phosphate of Lime.
	Ore.	Pig.	Ore.	Pig.				
1902....	13,641,459	4,470,420	25,000	17,988	1,299	17,235	2,141,355	71
1903....	13,935,748	4,573,202	26,993	20,278	831	14,377	2,041,851	87
1904....	13,994,670	4,596,803	26,796	20,155	8,896	16,307	2,370,391	71
1905....	14,824,183	(f)9,746,221	28,091	20,977	14,582	16,468	2,536,784	59
1906....	15,748,412	(f)9,999,211	30,710	22,693	23,126	14,437	2,586,851	Nil.
1907....	15,983,310	(f)9,850,953	33,053	24,853	16,356	14,927	2,732,968	Nil.
1908....	15,272,273	4,925,250	29,718	21,336	6,409	15,643	2,938,456	33
1909....	15,220,408	(f)9,818,916	30,221	22,823	2,812	16,575	3,014,678	9
1910....	15,470,392	5,055,595	28,992	21,867	5,554	16,782	3,180,520	4
1911....	15,768,511	5,101,089	24,186	18,279	5,067	14,819	3,166,838	(b)
1912....	8,552,343	**8,889,000**	25,729	.....	4,237	.....	3,235,942	(b)
1913....	9,746,178	**10,479,171**	24,656	.....	5,480	.....	3,333,048	.....
1914....	9,134,234	.....	26,422	.....	3,494	.....	3,323,144	.....

r.	Pyrite.	Salt.	Silica (Chert and Flint).	Silver. *Kg.*	Stone.			
					Igneous Rock.	Limestone. (*d*)	Sandstone.	Slate.
.....	9,315	1,893,881	100,938	4,560	5,554,696	12,368,196	5,571,121	525,665
.....	9,794	1,917,274	74,355	5,440	5,512,605	12,419,120	5,496,312	540,143
.....	10,452	1,921,899	66,300	4,967	6,084,642	12,235,825	5,391,265	572,181
.....	12,381	1,920,149	71,808	5,212	6,052,210	12,701,808	5,729,799	523,892
.....	11,318	1,996,593	69,300	(*b*)	6,264,402	12,962,725	5,345,328	500,546
.....	10,358	2,016,409	54,523	4,780	5,765,262	12,709,288	5,092,246	450,651
.....	9,600	1,873,555	64,813	4,207	6,211,860	11,977,007	5,105,481	420,979
.....	8,964	1,851,999	53,063	4,421	6,384,144	12,000,790	4,673,839	408,639
.....	10,393	2,083,543	75,089	4,251	6,714,774	12,713,565	4,456,679	423,006
.....	10,276	2,116,115	72,726	3,684	6,629,417	12,378,725	4,109,828	431,948
.....	10,691	.....	.....	.....	.....	.....	.....	.....
.....	11,611	2,285,221	76,105	.....	.....	12,953,008	4,043,591	376,935
.....	11,848	.....	.....	.....	.....	340,359	.....	.....

ear.	Strontium Sulphate.	Tin.		Tungsten Ore.	Uranium Ore.	Zinc.	
		Ore Dressed.	Block.			Ore.	Spelter.
.....	32,799	7,681	4,462	9	53	25,462	9,275
.....	23,209	7,500	4,351	276	6	25,287	9,430
.....	18,460	6,849	4,198	164	*Nil.*	28,097	10,427
.....	14,523	7,316	4,540	174	105	24,025	9,023
.....	14,338	6,376	(*b*)	267	11	23,189	(*b*)
.....	10,917	7,192	4,478	327	72	20,402	7,222
.....	16,733	8,137	5,133	237	72	15,469	5,926
.....	14,267	8,422	5,282	382	6	10,061	5,828
.....	4,838	7,693	4,874	275	76	11,418	4,235
.....	5,963	7,870	4,950	270	68	17,935	6,196
.....	.....	6,926	.....	192	43	17,988	.....
.....	18,732	7,054	.....	185	96	18,073	.....
.....	.....	6,742	.....	208	350	15,676	.....

From *Mineral Statistics of the United Kingdom*. (*b*) Not reported. (*c*) Bog ore, which is mined
nd, is an ore of iron, used principally for purifying gas. (*d*) Does not include chalk. (*e*) Includes
lay, potters' clay, and fuller's earth. (*f*) Includes production from imported ore. (*h*) Includes

MINERAL IMPORTS OF THE UNITED KINGDOM (*a*)

(In metric tons or dollars; £1 = $5)

Alkali.	Asphaltum.	Borax.	Coal, Coke, and Pat. Fuel.	Copper.			Iron and Steel.		
				Ore.	Regulus and Precipitate.	Wrought, Unwrought and Old.	Iron Ore.	Pig Iron.	Scrap.
)14,321	(*b*)	11,959	3,535	85,644	77,884	64,591	6,417,188	132,364	17,051
)14,325	(*b*)	16,012	2,812	80,771	67,739	90,717	6,198,368	132,494	19,326
)16,593	(*b*)	11,552	49,277	94,198	70,235	71,294	7,172,171	128,183	23,569
)14,070	(*b*)	16,955	49,269	97,789	76,073	75,487	7,634,839	90,674	36,559
)15,579	(*b*)	17,551	19,136	105,409	73,101	89,312	7,764,589	104,950	27,404
)13,732	(*b*)	(*n*)19,424	3,904	111,897	71,120	124,226	6,154,733	69,930	24,653
)10,857	(*b*)	(*n*)16,349	6,419	(*l*)90,579	(*l*)66,337	(*l*)133,758	(*l*)6,429,996	(*l*)111,300	(*l*)33,475
) 8,996	(*o*)14,415	16,277	36,615	99,755	70,081	89,279	7,133,483	173, 68	70,176
) 9,463	(*o*)20,866	20,621	30,672	87,986	65,914	101,059	6,448,462	[178,167	51,002
8,812	(*b*)	21,091	194,866	99,802	52,393	96,499	6,708,443	223,586	64,195
9,140	(*b*)	23,837	24,429	95,837	39,762	108,728	7,566,276	220,320	124,854
10,583	.....	20,493	45,315	72,766	43,252	152,974	5,799,918	227,099	112,405

Year.	Iron and Steel (*Continued*).								Lead.	
	Puddled and Wrought	Sheets and Plates.	Rails.	Strips, Wire, and Wire Rods.	Nails, Screws, Rivets, Bolts.	Steel Ingots, Blooms, Billets, etc.	Steel Bars, Shapes, Beams, Pillars.	Mnfrs. Unenumerated. (*h*)	Ore.	P
1902..	178,425	(*f*)	48,942	(*f*)	450,95	285,494	129,743	$14,424,835	25,838	
1903..	196,084	73,079	74,939	35,574	51,888	278,441	343,259	9,007,990	18,923	
1904..	109,289	69,552	40,438	38,214	50,649	531,069	219,510	8,630,380	8,748	
1905..	110,576	69,831	34,439	60,318	55,331	613,612	148,995	8,783,895	(*i*) 27,649	
1906..	111,062	83,747	11,900	61,288	57,071	493,805	149,363	7,824,405	(*i*) 30,795	
1907..	83,145	57,280	19,33	56,110	51,863	332,442	90,327	3,731,275	(*i*) 13,609	
1908(*i*)	85,270	56,652	31,393	109,313	54,251	437,238	231,859	3,034,895	23,861	
1909..	(*l*) 95,553	(*l*) 68,067	(*l*) 22,430	(*l*) 132,543	(*l*) 59,197	(*l*) 392,008	(*l*) 264,909	2,819,365	(*b*)	(*l*
1910..	(*l*) 98,859	88,245	16,074	163,681	58,977	361,401	349,662	3,239,715	(*b*)	
1911..	119,583	115,349	36,588	173,764	62,314	512,841	500,643	(*p*) 3,654,825	(*b*)	
1912..	167,774	103,224	24,640	205,749	73,745	607,470	509,002	4,270,000	(*b*)	
1913..	204,218	172,301	38,701	225,690	66,086	568,512	597,591	10,098,040	(*b*)	
1914..	132,194	121,433	24,033	179,772	62,317	325,245	459,771	8,852,884	.....	

Year.	Manganese Ore.	Mica, Sheet.	Mica and Talc.	Paraffin.	Petroleum. *Liters.*	Phosphate Rock.	Platinum, Wrought and Unwrought. *Kg.*	Potassium Nitrate.	P I (
1902.....	237,066	1,078	6,127	52,023	1,078,095,152	370,697	3,027	11,526	
1903.....	235,574	(*b*)	(*b*)	49,163	1,299,570,625	398,997	(*b*)	9,425	
1904.....	208,458	(*b*)	(*b*)	42,882	1,373,488,176	425,978	(*b*)	12,277	
1905.....	289,827	(*b*)	(*b*)	41,247	1,364,301,583	427,762	(*b*)	8,260	
1906.....	314,016	(*b*)	(*b*)	44,673	1,130,667,737	450,058	(*b*)	10,125	
1907.....	513,750	(*b*)	(*b*)	46,542	1,382,595,355	512,601	(*b*)	10,719	
1908 (*i*)....	349,694	(*b*)	(*b*)	(*n*) 46,504	(*n*) 1,300,726,576	537,628	(*b*)	(*n*) 11,913	
1909.....	335,813	(*b*)	(*b*)	(*n*) 53,289	(*n*) 1,355,562,599	459,058	(*b*)	(*n*) 10,704	(*l*
1910.....	489,948	(*b*)	(*b*)	(*n*) 54,073	(*n*) 1,308,396,240	462,905	(*b*)	11,558	
1911.....	364,676	(*b*)	(*b*)	51,456	1,661,100,144	501,332	(*b*)	11,376	
1912.....	393,798	(*b*)	(*b*)	74,836	1,879,486,588	528,620	(*b*)	11,034	
1913.....	611,227	(*b*)	(*b*)	57,974 (*g*)	488,106,963	548,000	(*b*)	12,092	
1914.....	487,426	.....	.....	53,576 (*g*)	646,894,523	564,865	.....	10,666	

Year.	Quicksilver.	Silver Ore. (*d*)	Sodium Nitrate.	Sulphur.	Tin.		Zinc.	
					Ore.	Block, Ingot, Bars or Slabs.	Ore.	Spelter.
1902.....	1,129	$5,383,515	116,791	23,863	12,255	37,713	45,312	89,688
1903.....	1,187	6,596,045	118,582	21,313	12,473	36,076	41,009	86,539
1904.....	1,130	8,271,480	122,454	17,629	15,734	39,932	54,438	90,088
1905.....	1,158	10,426,570	106,107	18,163	(*b*)	40,391	23,909	92,261
1906.....	1,320	10,532,020	110,222	22,704	21,003	44,306	(*i*) 22,824	92,203
1907.....	1,341	11,224,650	115,716	15,730	21,205	44,505	(*i*) 66,076	90,56
1908(*i*).....	1,483	10,743,400	(*n*) 148,056	(*n*) 19,580	25,414	48,496	61,661	91,48
1909.....	(*m*) 1,469	10,409,800	(*n*) 91,650	21,211	(*m*) 24,471	(*l*) 42,393	(*b*)	104,17
1910.....	1,517	9,311,665	128,528	20,496	26,490	47,028	(*b*)	123,01
1911.....	1,584	8,420,954	130,549	21,269	29,300	46,643	(*b*)	117,07
1912.....	1,607	7,523,692	125,664	22,109	29,112	43,850	(*b*)	139,46
1913.....	1,543	5,718,552	143,275	18,518	35,169	46,443	(*b*)	147,42
1914.....	1,278	4,324,576	174,775	22,162	32,938	41,644	.....	117,660

(*a*) From *Accounts Relating to Trade and Navigation of the United Kingdom.* (*b*) Not reported. (*c* sified as soda compounds since 1901. (*d*) Includes the value of silver in argentiferous ore and (*f*) Not separately enumerated. (*g*) Gallons. (*h*) Prior to 1900, many manufactures were not s separately. (*i*) From *Mines and Quarries.* (*l*) From *Iron and Coal Trades Review.* (*m*) *Min.* (*n*) *Oil, Paint and Drug Reporter.* (*o*) From Trinidad. (*p*) There are besides, not here given, pi es ings and forgings amounting to 51,000 tons.

MINERAL EXPORTS OF THE UNITED KINGDOM—DOMESTIC PRODUCTS (a)
(In metric tons or dollars; £1 = $5)

Year.	Bleaching Materials.	Cement.	Coal.	Coke.	Patent Fuel.	Supplied to Steamers.	Coal Products. (c)
1902	40,939	308,104	43,849,591	669,664	1,067,060	15,390,485	5,991,025
1903	49,415	406,388	45,669,258	728,957	970,449	17,068,646	7,290,825
1904	35,289	390,736	46,995,636	779,060	1,257,589	17,465,954	6,879,400
1905	42,526	463,863	48,236,334	786,498	1,126,190	17,674,484	6,742,455
1906	45,510	668,461	56,489,367	828,266	1,399,244	18,887,656	7,226,790
1907	48,856	777,741	64,621,743	997,170	1,504,661	18,917,660	7,726,685
1908	39,120	607,950	63,551,057	1,212,184	1,463,557	19,786,734	(n) 7,711,360
1909(k)...	(n) 46,321	607,825	64,089,132	(l) 1,180,218	(l) 1,479,142	20,029,427	(n) 7,276,050
1910	(n) 51,188	747,627	(l) 63,081,948	979,526	1,494,397	(l) 19,839,123	(n) 8,398,405
1911	46,416	727,092	65,636,084	1,076,887	1,638,625	19,573,379	£2,517,355
1912.....	41,989	656,460	65,479,346	1,042,489	1,590,557	18,584,946	£2,981,159
1913	36,928	761,232	74,623,453	1,254,502	2,087,407	21,382,032	£2,279,790
1914	30,458	608,344	60,023,878	1,202,562	1,634,553	18,844,505	.....

Year.	Copper.				Iron.				
	Ingot.	Mixed or Yellow Metal.	Mfrs.	Sulphate.	Ore.	Pig.	Scrap.	Cast Iron and Mfrs.	Wrought Iron, Shapes and Mfrs.
1902 ...	26,935	13,314	14,075	43,995	4,062	1,120,207	104,890	(b)	(b)
1903 ...	23,723	14,425	16,975	54,307	4,534	1,082,426	143,929	62,249	217,139
1904 ...	14,791	16,704	18,467	71,367	6,706	823,909	166,010	49,004	173,233
1905 ...	21,232	9,959	22,128	55,219	14,664	997,601	151,619	49,193	186,340
1906 ...	19,778	7,149	16,195	43,670	13,415	1,670,753	180,547	54,878	203,521
1907 ...	25,652	7,994	16,676	46,049	15,538	1,978,350	162,295	43,218	215,159
1908(k)	14,869	15,546	19,796	(m) 72,429	4,478	1,317,330	135,115	48,336	174,539
1909 ...	12,465	(m) 11,381	17,248	(m) 45,547	(l) 5,185	(l) 1,026,517	(l) 165,183	(l) 44,406	(l) 171,698
1910 ...	11,898	(m) 15,970	12,551	43,391	(l) 7,464	(l) 1,062,444	(l) 150,507	(l) 57,148	(q) 143,707
1911 ...	10,970	15,101	24,669	81,112	(l) 6,352	1,222,622	147,759	(l) 70,618	140,312
1912 ...	12,993	11,108	19,327	85,497	6,241	1,284,220	127,610	68,676	144,747
1913 ...	15,165	14,711	22,317	76,950	5,278	1,142,917	117,645	82,816	139,593
1914 ...	7,390	13,420	18,367	69,015	13,742	793,703	90,037	73,339	91,912

Year.	Iron (*Continued*).								
	Rails.	Wire and Mfrs. of.	Plates and Sheets.	Galvanized Sheets.	Black Plates for Tinning.	Tinned Plates.	Steel Ingots, Billets, Blooms, etc.	Steel Shapes, Beams, and Pillars.	Total Iron and Steel, and Mfrs. of.
1902 ..	(b)	(b)	(b)	336,572	58,245	317,201	306,152	(b)	3,529,225
1903 ..	613,741	60,800	165,672	357,665	66,279	297,485	13,427	159,330	3,621,637
1904 ..	533,895	61,894	154,774	391,608	63,467	365,262	4,324	176,232	3,315,049
1905 ..	555,390	82,519	207,866	413,533	69,937	360,630	8,735	219,491	3,781,058
1906 ..	470,652	96,641	279,459	450,221	66,749	381,421	11,924	311,231	4,763,868
1907 ..	595,272	103.100	305,399	476,838	72,675	411,814	13,705	344,135	5,249,028
1908(k)	589,525	95,801	210,526	396,366	62,079	409,335	2,452	278,792	4,162,065
1909 ..	(l) 589,499	(l) 107,406	(l) 169,918	(l) 502,791	(l) 61,025	(l) 446,781	(l) 3,217	(l) 309,555	4,278,172
1910 ..	490,068	(l) 124,703	(l) 197,858	(l) 606,530	(l) 56,691	(l) 490,733	(l) 3,340	(q) 230,850	4,661,647
1911 ..	381,320	(l) 129,252	(l) 203,850	627,215	(l) 68,137	492,104	(l) 4,376	231,793	4,588,385
1912 ..	418,742	121,215	218,585	669,252	66,775	488,629	4,241	245,033	4,891,270
1913 ..	517,251	118,814	204,452	774,948	72,977	503,170	4,942	255,580	5,017,456
1914 ..	451,030	100,938	145,017	576,044	58,192	442,755	5,784	204,726	3,953,722

UNITED KINGDOM

The statistics of the mineral production, imports and exports, according to official reports, are given in the subjoined tables. Figures given in full-faced type are either provisional figures or estimates.

MINERAL AND METALLURGICAL PRODUCTION OF THE UNITED KINGDOM (a)
(In metric tons)

Year.	Alum Shale.	Arsenious Acid.	Arsenical Pyrites.	Barium Minerals.	Bauxite.	Chalk.	Clay. (c)	Coal.
1902....	5,755	2,165	842	23,986	9,192	4,466,004	15,549,002	230,728,562
1903....	3,337	916	58	24,659	6,226	4,541,494	16,460,526	234,019,821
1904....	6,636	992	44	26,748	8,839	4,509,768	16,210,734	236,130,373
1905....	7,245	1,552	651	29,528	7,417	4,608,153	15,376,910	239,906,999
1906....	9,605	1,625	650	36,319	6,760	4,825,299	12,459,213	255,067,622
1907....	10,063	1,523	1,800	42,648	7,658	4,855,857	15,065,141	272,097,858
1908....	5,459	2,007	3,270	39,572	11,904	4,329,983	14,638,710	265,726,332
1909....	9,266	2,926	182	42,436	9,652	4,508,136	14,293,598	268,007,890
1910....	6,781	2,187	958	45,384	4,208	4,705,766	(h)14,316,469	268,677,182
1911....	10,685	2,178	1,189	44,826	6,103	.....	14,057,090	276,255,764
1912....	.....	2,228	1,806	43,453	5,882	4,962,408	.....	264,749,661
1913....	8,887	1,716	36	48,792	6,153	4,939,095	14,090,818	292,047,544
1914....	.....	1,722	.....	46,675	8,420	.....	.....	270,070,414

Year.	Copper.		Fluorspar.	Gold.		Gravel and Sand.	Gypsum.	Bog Ore (Ireland). (c)
	Ore and Precipitate.	Fine.		Ore.	Bullion. *Kg.*			
1902.....	6,210	490	6,388	30,432	130.0	2,100,829	228,264	4,983
1903.....	6,977	545	12,102	29,057	171.0	2,281,689	223,426	4,156
1904.....	5,552	501	18,450	23,574	610.7	2,275,426	237,749	4,616
1905.....	7,267	727	40,079	16,237	169.0	2,277,486	259,596	3,256
1906.....	7,882	(b)	42,521	17,662	(b)	2,404,857	228,627	5,512
1907.....	6,867	677	50,257	13,186	59.4	2,438,798	239,285	6,391
1908.....	5,528	588	35,257	7,237	28.5	2,228,245	231,980	4,364
1909.....	3,777	442	43,165	5,627	37.6	2,199,583	242,832	2,719
1910.....	4,245	456	62,607	6,252	75.5	2,235,160	259,661	2,603
1911.....	3,314	398	56,117	2,796	13.2	2,311,694	281,125	2,743
1912.....	1,942	.....	29,154	173	(b)	.....	247,724	(b)
1913.....	2,108	.....	54,557	4	.....	2,449,305	242,341	.....
1914.....	2,561	.....	.....	55	.....	.....	223,764	.....

Year.	Iron.		Lead.		Manganese Ore.	Mineral Paints.	Oil Shale.	Phosphate of Lime.
	Ore.	Pig.	Ore.	Pig.				
1902....	13,641,459	4,470,420	25,000	17,988	1,299	17,235	2,141,355	71
1903....	13,935,748	4,573,202	26,993	20,278	831	14,377	2,041,851	87
1904....	13,994,670	4,596,803	26,796	20,155	8,896	16,307	2,370,391	71
1905....	14,824,183	(f)9,746,221	28,091	20,977	14,582	16,468	2,536,784	59
1906....	15,748,412	(f)9,999,211	30,710	22,693	23,126	14,437	2,586,851	Nil.
1907....	15,983,310	(f)9,850,953	33,053	24,853	16,356	14,927	2,732,968	Nil.
1908....	15,272,273	4,925,250	29,718	21,336	6,409	15,643	2,938,456	33
1909....	15,220,408	(f)9,818,916	30,221	22,823	2,812	16,575	3,014,678	9
1910....	15,470,392	5,055,595	28,992	21,867	5,554	16,782	3,180,520	4
1911....	15,768,511	5,101,089	24,186	18,279	5,067	14,819	3,166,838	(b)
1912....	8,552,343	**8,889,000**	25,729	.....	4,237	.....	3,235,942	(b)
1913....	9,746,178	**10,479,171**	24,656	.....	5,480	.....	3,333,048	.....
1914....	9,134,234	.....	26,422	.....	3,494	.....	3,323,144	.....

MINERAL EXPORTS OF THE UNITED KINGDOM—DOMESTIC PRODUCTS (*a*)
(In metric tons or dollars; £1 = $5)

ear.	Bleaching Materials.	Cement.	Coal.	Coke.	Patent Fuel.	Supplied to Steamers.	Coal Products. (*c*)
.....	40,939	308,104	43,849,591	669,664	1,067,060	15,390,485	5,991,025
.....	49,415	406,388	45,669,258	728,957	970,449	17,068,646	7,290,825
.....	35,289	390,736	46,995,636	779,060	1,257,589	17,465,954	6,879,400
.....	42,526	463,863	48,236,334	786,498	1,126,190	17,674,484	6,742,455
.....	45,510	668,461	56,489,367	828,266	1,399,244	18,887,656	7,226,790
.....	48,856	777,741	64,621,743	997,170	1,504,661	18,917,660	7,726,685
.....	39,120	607,950	63,551,057	1,212,184	1,463,557	19,786,734	(*n*) 7,711,360
(*k*)...	(*n*) 46,321	607,825	64,089,132	(*l*) 1,180,218	(*l*) 1,479,142	20,029,427	(*n*) 7,276,050
.....	(*n*) 51,188	747,627	(*l*) 63,081,948	979,526	1,494,397	(*l*) 19,839,123	(*n*) 8,398,405
.....	46,416	727,092	65,636,084	1,076,887	1,638,625	19,573,379	£2,517,355
.....	41,989	656,460	65,479,346	1,042,489	1,590,557	18,584,946	£2,981,159
.....	36,928	761,232	74,623,453	1,254,502	2,087,407	21,382,032	£2,279,790
.....	30,458	608,344	60,023,878	1,202,562	1,634,553	18,844,505	.....

ar.	Copper.				Iron.				
	Ingot.	Mixed or Yellow Metal.	Mfrs.	Sulphate.	Ore.	Pig.	Scrap.	Cast Iron and Mfrs.	Wrought Iron, Shapes and Mfrs.
2 ...	26,935	13,314	14,075	43,995	4,062	1,120,207	104,890	(*b*)	(*b*)
3 ...	23,723	14,425	16,975	54,307	4,534	1,082,426	143,929	62,249	217,139
4 ...	14,791	16,704	18,467	71,367	6,706	823,909	166,010	49,004	173,233
5 ...	21,232	9,959	22,128	55,219	14,664	997,601	151,619	49,193	186,340
6 ...	19,778	7,149	16,195	43,670	13,415	1,670,753	180,547	54,876	203,521
7 ...	25,652	7,994	16,676	46,049	15,538	1,978,350	162,295	43,218	215,159
8(*k*)	14,869	15,546	19,796	(*m*) 72,429	4,478	1,317,330	135,115	48,336	174,539
9 ...	12,465	(*m*) 11,381	17,248	(*m*) 45,547	(*l*) 5,185	(*l*) 1,026,517	(*l*) 165,183	(*l*) 44,406	(*l*) 171,698
0 ...	11,898	(*m*) 15,970	12,551	43,391	(*l*) 7,464	(*l*) 1,062,444	(*l*) 150,507	(*l*) 57,148	(*q*) 143,707
1 ...	10,970	15,101	24,669	81,112	(*l*) 6,352	1,222,622	147,759	(*l*) 70,618	140,312
2 ...	12,993	11,108	19,327	85,497	6,241	1,284,220	127,610	68,676	144,747
3 ...	15,165	14,711	22,317	76,950	5,278	1,142,917	117,645	82,816	139,593
4 ...	7,390	13,420	18,367	69,015	13,742	793,703	90,037	73,339	91,912

ar.	Iron (*Continued*).								
	Rails.	Wire and Mfrs. of.	Plates and Sheets.	Galvanized Sheets.	Black Plates for Tinning.	Tinned Plates.	Steel Ingots, Billets, Blooms, etc.	Steel Shapes, Beams, and Pillars.	Total Iron and Steel, and Mfrs. of.
2 ..	(*b*)	(*b*)	(*b*)	336,572	58,245	317,201	306,152	(*b*)	3,529,225
3 ..	613,741	60,800	165,672	357,665	66,279	297,485	13,427	159,330	3,621,637
4 ..	533,895	61,894	154,774	391,608	63,467	365,262	4,324	176,232	3,315,049
5 ..	555,390	82,519	207,866	413,533	69,937	360,630	8,735	219,491	3,781,058
6 ..	470,652	96,641	279,459	450,221	66,749	381,421	11,924	311,231	4,763,868
7 ..	595,272	103.100	305,399	476,838	72,675	411,814	13,705	344,135	5,249,028
8(*k*)	589,525	95,801	210,526	396,366	62,079	409,335	2,452	278,792	4,162,065
9 ..	(*l*) 589,499	(*l*) 107,406	(*l*) 169,918	(*l*) 502,791	(*l*) 61,025	(*l*) 446,781	(*l*) 3,217	(*l*) 309,555	4,278,172
0 ..	490,068	(*l*) 124,703	(*l*) 197,858	(*l*) 606,530	(*l*) 56,691	(*l*) 490,733	(*l*) 3,340	(*q*) 230,850	4,661,647
1 ..	381,320	(*l*) 129,252	(*l*) 203,850	627,215	(*l*) 68,137	492,104	(*l*) 4,376	231,793	4,588,385
2 ..	418,742	121,215	218,585	669,252	66,775	488,629	4,241	245,033	4,891,270
3 ..	517,251	118,814	204,452	774,948	72,977	503,170	4,942	255,580	5,017,456
4 ..	451,030	100,938	145,017	576,044	58,192	442,755	5,784	204,726	3,953,722

Year.	Iron and Steel (*Continued*).								Lead	
	Puddled and Wrought	Sheets and Plates.	Rails.	Strips, Wire, and Wire Rods.	Nails, Screws, Rivets, Bolts.	Steel Ingots, Blooms, Billets, etc.	Steel Bars, Shapes, Beams, Pillars.	Mnfrs. Unenumerated. (*h*)	Ore.	
1902..	178,425	(*f*)	48,942	(*f*)	450,95	285,494	129,743	$14,424,835	25,838	
1903..	196,084	73,079	74,939	35,574	51,888	278,441	343,259	9,007,990	18,923	
1904..	109,289	69,552	40,438	38,214	50,649	531,069	219,510	8,630,380	8,748	
1905..	110,576	69,831	34,439	60,318	55,331	613,612	148,995	8,783,895	(*i*) 27,649	
1906..	111,062	83,747	11,900	61,288	57,071	493,805	149,363	7,824,405	(*i*) 30,795	
1907..	83,145	57,280	19,33	56,110	51,863	332,442	90,327	3,731,275	(*i*) 13,609	
1908(*i*)	85,270	56,652	31,393	109,313	54,251	437,238	231,859	3,034,895	23,861	
1909..	(*l*) 95,553	(*l*) 68,067	(*l*) 22,430	(*l*) 132,543	(*l*) 59,197	(*l*) 392,008	(*l*) 264,909	2,819,365	(*b*)	(*l*)
1910..	(*l*) 98,859	88,245	16,074	163,681	58,977	361,401	349,662	3,239,715	(*b*)	
1911..	119,583	115,349	36,588	173,764	62,314	512,841	500,643	(*p*) 3,654,825	(*b*)	
1912..	167,774	103,224	24,640	205,749	73,745	607,470	509,002	4,270,000	(*b*)	
1913..	204,218	172,301	38,701	225,690	66,086	568,512	597,591	10,098,040	(*b*)	
1914..	132,194	121,433	24,033	179,772	62,317	325,245	459,771	8,852,884	.....	

Year.	Manganese Ore.	Mica, Sheet.	Mica and Talc.	Paraffin.	Petroleum. *Liters.*	Phosphate Rock.	Platinum, Wrought and Unwrought. *Kg.*	Potassium Nitrate.	
1902.....	237,066	1,078	6,127	52,023	1,078,095,152	370,697	3,027	11,526	
1903.....	235,574	(*b*)	(*b*)	49,163	1,299,570,625	398,997	(*b*)	9,425	
1904.....	208,458	(*b*)	(*b*)	42,882	1,373,488,176	425,978	(*b*)	12,277	
1905.....	289,827	(*b*)	(*b*)	41,247	1,364,301,583	427,762	(*b*)	8,260	
1906.....	314,016	(*b*)	(*b*)	44,673	1,130,667,737	450,058	(*b*)	10,125	
1907.....	513,750	(*b*)	(*b*)	46,542	1,382,595,355	512,601	(*b*)	10,719	
1908 (*i*)....	349,694	(*b*)	(*b*)	(*n*) 46,504	(*n*) 1,300,726,576	537,628	(*b*)	(*n*) 11,913	
1909.....	335,813	(*b*)	(*b*)	(*n*) 53,289	(*n*) 1,355,562,599	459,058	(*b*)	(*n*) 10,704	(*l*)
1910.....	489,948	(*b*)	(*b*)	(*n*) 54,073	(*n*) 1,308,396,240	462,905	(*b*)	11,558	
1911.....	364,676	(*b*)	(*b*)	51,456	1,661,100,144	501,332	(*b*)	11,376	
1912.....	393,798	(*b*)	(*b*)	74,836	1,879,486,588	528,620	(*b*)	11,034	
1913.....	611,227	(*b*)	(*b*)	57,974	(*g*) 488,106,963	548,000	(*b*)	12,092	
1914.....	487,426	.....	.....	53,576	(*g*) 646,894,523	564,865	.....	10,666	

Year.	Quicksilver.	Silver Ore. (*d*)	Sodium Nitrate.	Sulphur.	Tin.		Zinc.	
					Ore.	Block, Ingot, Bars or Slabs.	Ore.	Spelter.
1902.....	1,129	$5,383,515	116,791	23,863	12,255	37,713	45,312	89,688
1903.....	1,187	6,596,045	118,582	21,313	12,473	36,076	41,009	86,539
1904.....	1,130	8,271,480	122,454	17,629	15,734	39,932	54,438	0,088
1905.....	1,158	10,426,570	106,107	18,163	(*b*)	40,391	23,909	9,261
1906.....	1,320	10,532,020	110,222	22,704	21,003	44,306	(*i*) 22,824	9,203
1907.....	1,341	11,224,650	115,716	15,730	21,205	44,505	(*i*) 66,076	90,56
1908(*i*).....	1,483	10,743,400	(*n*) 148,056	(*n*) 19,580	25,414	48,496	61,661	91,48
1909.....	(*m*) 1,469	10,409,800	(*n*) 91,650	21,211	(*m*) 24,471	(*l*) 42,393	(*b*)	104,27
1910.....	1,517	9,311,665	128,528	20,496	26,490	47,028	(*b*)	123,01
1911.....	1,584	8,420,954	130,549	21,269	29,300	46,643	(*b*)	117,07
1912.....	1,607	7,523,692	125,664	22,109	29,112	43,850	(*b*)	139,46
1913.....	1,543	5,718,552	143,275	18,518	35,169	46,443	(*b*)	147,42
1914.....	1,278	4,324,576	174,775	22,162	32,938	41,644	.....	117,660

(*a*) From *Accounts Relating to Trade and Navigation of the United Kingdom.* (*b*) Not reported. sified as soda compounds since 1901. (*d*) Includes the value of silver in argentiferous ore an (*f*) Not separately enumerated. (*g*) Gallons. (*h*) Prior to 1900, many manufactures were not separately. (*i*) From *Mines and Quarries.* (*l*) From *Iron and Coal Trades Review.* (*m*) *Min* (*n*) *Oil, Paint and Drug Reporter.* (*o*) From Trinidad. (*p*) There are besides, not here given, pip ings and forgings amounting to 51,000 tons.

MINERAL EXPORTS OF THE UNITED KINGDOM—DOMESTIC PRODUCTS (a)
(In metric tons or dollars; £1 = $5)

Year.	Bleaching Materials.	Cement.	Coal.	Coke.	Patent Fuel.	Supplied to Steamers.	Coal Products. (c)
12	40,939	308,104	43,849,591	669,664	1,067,060	15,390,485	5,991,025
13	49,415	406,388	45,669,258	728,957	970,449	17,068,646	7,290,825
14	35,289	390,736	46,995,636	779,060	1,257,589	17,465,954	6,879,400
15	42,526	463,863	48,236,334	786,498	1,126,190	17,674,484	6,742,455
16	45,510	668,461	56,489,367	828,266	1,399,244	18,887,656	7,226,790
17	48,856	777,741	64,621,743	997,170	1,504,661	18,917,660	7,726,685
18	39,120	607,950	63,551,057	1,212,184	1,463,557	19,786,734	(n) 7,711,360
19(k)	(n) 46,321	607,825	64,089,132	(l) 1,180,218	(l) 1,479,142	20,029,427	(n) 7,276,050
20	(n) 51,188	747,627	(l) 63,081,948	979,526	1,494,397	(l) 19,839,123	(n) 8,398,405
21	46,416	727,092	65,636,084	1,076,887	1,638,625	19,573,379	£2,517,355
22	41,989	656,460	65,479,346	1,042,489	1,590,557	18,584,946	£2,981,159
23	36,928	761,232	74,623,453	1,254,502	2,087,407	21,382,032	£2,279,790
24	30,458	608,344	60,023,878	1,202,562	1,634,553	18,844,505	.....

Year.	Copper.				Iron.				
	Ingot.	Mixed or Yellow Metal.	Mfrs.	Sulphate.	Ore.	Pig.	Scrap.	Cast Iron and Mfrs.	Wrought Iron, Shapes and Mfrs.
12	26,935	13,314	14,075	43,995	4,062	1,120,207	104,890	(b)	(b)
13	23,723	14,425	16,975	54,307	4,534	1,082,426	143,929	62,249	217,139
14	14,791	16,704	18,467	71,367	6,706	823,909	166,010	49,004	173,233
15	21,232	9,959	22,128	55,219	14,664	997,601	151,619	49,193	186,340
16	19,778	7,149	16,195	43,670	13,415	1,670,753	180,547	54,876	203,521
17	25,652	7,994	16,676	46,049	15,538	1,978,350	162,295	43,218	215,159
18(k)	14,869	15,546	19,796	(m) 72,429	4,478	1,317,330	135,115	48,336	174,539
19	12,465	(m) 11,381	17,248	(m) 45,547	(l) 5,185	(l) 1,026,517	(l) 165,183	(l) 44,406	(l) 171,698
20	11,898	(m) 15,970	12,551	43,391	(l) 7,464	(l) 1,062,444	(l) 150,507	(l) 57,148	(q) 143,707
21	10,970	15,101	24,669	81,112	(l) 6,352	1,222,622	147,759	(l) 70,618	140,312
22	12,993	11,108	19,327	85,497	6,241	1,284,220	127,610	68,676	144,747
23	15,165	14,711	22,317	76,950	5,278	1,142,917	117,645	82,816	139,593
24	7,390	13,420	18,367	69,015	13,742	793,703	90,037	73,339	91,912

Year.	Iron (*Continued*).								
	Rails.	Wire and Mfrs. of.	Plates and Sheets.	Galvanized Sheets.	Black Plates for Tinning.	Tinned Plates.	Steel Ingots, Billets, Blooms, etc.	Steel Shapes, Beams, and Pillars.	Total Iron and Steel, and Mfrs. of.
12	(b)	(b)	(b)	336,572	58,245	317,201	306,152	(b)	3,529,225
13	613,741	60,800	165,672	357,665	66,279	297,485	13,427	159,330	3,621,637
14	533,895	61,894	154,774	391,608	63,467	365,262	4,324	176,232	3,315,049
15	555,390	82,519	207,866	413,533	69,937	360,630	8,735	219,491	3,781,058
16	470,652	96,641	279,459	450,221	66,749	381,421	11,924	311,231	4,763,868
17	595,272	103,100	305,399	476,838	72,675	411,814	13,705	344,135	5,249,028
18(k)	589,525	95,801	210,526	396,366	62,079	409,335	2,452	278,792	4,162,065
19	(l) 589,499	(l) 107,406	(l) 169,918	(l) 502,791	(l) 61,025	(l) 446,781	(l) 3,217	(l) 309,555	4,278,172
20	490,068	(l) 124,703	(l) 197,858	(l) 606,530	(l) 56,691	(l) 490,733	(l) 3,340	(q) 230,850	4,661,647
21	381,320	(l) 129,252	(l) 203,850	627,215	(l) 68,137	492,104	(f) 4,376	231,793	4,588,385
22	418,742	121,215	218,585	669,252	66,775	488,629	4,241	245,033	4,891,270
23	517,251	118,814	204,452	774,948	72,977	503,170	4,942	255,580	5,017,456
24	451,030	100,938	145,017	576,044	58,192	442,755	5,784	204,726	3,953,722

Year.	Lead, Pig and Mfrs.	Salt.	Sodium.				Tin, Block	Zinc.		
			Soda Ash.	Carbonate and Bicarbonate.	Hydrate.	Sulphate.		Ore.	Spelter.	Mfrs.
1902 ..	33,537	624,752	59,894	24,654	61,658	35,672	6,210	16,717	6,756	1,345
1903 ..	36,152	594,300	58,605	23,574	59,725	45,630	6,349	15,659	8,192	(i)
1904 ..	35,600	632,605	61,327	25,252	61,985	40,324	5,953	14,606	7,930	(i)
1905 ..	42,265	588,389	67,678	28,425	68,675	33,681	7,741	(b)	7,451	(i)
1906 ..	45,612	629,658	86,232	26,970	72,218	44,448	8,631	(b)	7,962	(i)
1907 ..	44,068	592,989	91,120	29,539	70,432	45,898	8,808	11,511	6,666	(i)
1908(k)	50,221	532,101	(n) 83,713	(n) 20,805	(n) 73,769	(n) 22,974	9,486	3,833	8,537	(i)
1909 ..	(m) 46,399	523,690	(n) 97,480	(n) 23,378	(n) 80,439	(n) 35,587	11,373	(b)	(m) 8,684	(i)
1910 ..	47,588	571,845	110,188	23,295	84,291	58,960	12,576	(b)	9,247	(i)
1911 ..	44,733	614,572	125,945	26,353	82,356	59,382	11,736	(b)	9,736	(i)
1912 ..	47,782	557,291	144,073	29,403	79,527	50,759	12,152	(b)	10,881	.....
1913 ..	49,261	542,157	159,714	39,175	76,152	67,504	11,687	....	11,313	.....
1914 ..	36,486	504,848	181,754	37,724	75,618	40,366	13,599	.....	7,580	.....

(a) From *Accounts Relating to Trade and Navigation of the United Kingdom.* (b) Not reported. (c) Including naphtha, paraffin, paraffin oil and petroleum. (d) Previous reports not available. (e) Includes puddled iron. (f) Includes railroad material of all kinds. (g) Includes all soda compounds; not separate; enumerated previous to 1901. (h) Included under soda ash. (i) Included under spelter. (k) From *Mines and Quarries.* (l) From *Iron and Coal Trades Review.* (m) *Mining Journal.* (n) From *Oil Paint and Drug Reporter.* (q) Bars only.

UNITED STATES

Of the following tables, the first records the imports of foreign mineral and metal products into the United States, whether dutiable or duty-free; the second shows the exports of materials produced in the United States; and the third reports the re-exports of products of foreign origin. These statistics are as reported by the Bureau of Statistics of the Department of Commerce and Labor, and special acknowledgment is due to the Chief of this Bureau, for furnishing the figures for many substances which are not reported in the Monthly Summary. The complete statement of production in the United States is given under the separate chapters.

IMPORTS (*a*)

Year.	Aluminium. Crude. Lb.	Kg.	Value.	Value per Lb.	Ammonium Sulphate. Lb.	Metric Tons.	Value.	Value per Lb.
1905	530,429	240,284	$106,108	$0.200	15,512,399	7,038	$416,048	$0.027
1906	770,713	349,195	154,292	0.200	31,797,291	14,423	894,663	0.028
1907	872,474	395,754	181,352	0.208	70,440,992	31,960	1,828,236	0.026
1908	465,317	210,785	80.268	0.173	76,475,104	34,698	1,982,830	0.026
1909	5,109,843	2,317,784	745,963	0.145	85,829,334	38,932	2,114,694	0.024
1910	(*o*)12,271,277	5,567,730	1,844,830	0.151	184,686,534	83,795	4,668,820	0.025
1911	4,173,308	1,893,000	598,272	0.143	189,265,797	85,850	5,066,470	0.027
1912	22,759,937	10,326,650	3,092,889	0.136	119,085,120	54,049	3,447,225	0.029
1913	23,185,775	10,519,861	3,905,977	0.169	130,549,440	59,252	3,957,307	0.030
1914	16,241,340	7,369,029	2,729,383	0.168	166,031,040	75,356	4,475,603	0.027

Year.	Antimony. (*r*) Lb.	Metric Tons.	Value.	Value per Lb.	Antimony Ore. Lb.	Metric Tons.	Value.	Value per Lb.
1905....	5,737,891	2,603	$431,774	$0.075	1,976,694	897	$52,868	$0.027
1906....	7,900,194	3,583	1,417,816	0.179	2,247,131	1,019	128,347	0,057
1907....	8,662,683	3,928	1,423,276	0,164	2,780,186	1,261	180,903	0.065
1908....	8,114,651	3,954	572,979	0.071	3,280,922	1,488	106,930	0.033
1909....	9,652,568	4,335	619,179	0.064	3,386,708	1,575	94,249	0.027
1910....	9,899,514	4,487	572,031	0.058	*Nil.*	.....	.....	.....
1911....	10,957,844	4,970	573,564	0.052	*Nil.*	.....	.....	.....
1912...	17,645,870	8,006	936,920	0.053	*Nil.*	.....	.....	.....
1913....	15,333,492	6,957	878,773	0.057	76,160	34	1,739	0.023
1914....	13,070,381	5,930	737,233	0.056	2,824,640	1,281	54,408	0.019

Year.	Asbestos. Crude, Value.	Mfd., Value.	Total Value.	Asphaltum. Long Tons.	Metric Tons.	Value.	Value per L. T.
1905 ...	$776,362	$70,117	$846,749	86,748	88,136	$382,667	$4.41
1906 ...	536,500	.....	.....	97,274	98,830	388,010	3.93
1907 ...	1,104,109	200,371	1,304,480	127,902	129,948	518,074	4.05
1908 ...	1,068,342	147,548	.1,215,869	131,862	133,971	587,698	4.45
1909 ...	993,254	240,381	1,233,635	132,807	134,939	646,655	4.87
1910 ...	1,235,170	308,078	1,543,248	166,379	169,041	776,283	4.66
1911 ...	1,413,541	161,442	1,574,983	174,234	177,030	778,185	4.47
1912 ..	1,456,012	363,759	1,819,771	194,775	198,021	919,467	4.72
1913...	1,928,705	389,664	2,318,369	193,783	197,012	911,921	4.71
1914 ...	1,407,758	368,344	1,776,102	124,214	126,284	682,748	5.50

Year.	Arsenic. (b)				Barytes.				Bauxite.			
	Lb.	Metric Tons.	Value.	Value per Lb.	Long Tons.	Metric Tons.	Value.	Value per L. T.	Long Tons.	Metric Tons.	Value.	Value per L. T.
1905....	6,444,083	2,924	$219,198	$0.034	7,879	8,005	$36,796	$4.67	11,726	11,914	$46,517	$3.96
1906....	7,639,507	3,464	336,609	0.044	4,293	4,362	37,296	8.69	17,809	18,094	63,221	3.55
1907....	9,922,870	4,500	553,440	0.056	28,350	28,804	174,225	6.15	25,065	25,466	93,208	3.72
1908....	9,592,881	4,558	417,137	0.056	n)12,196	12,390	58,822	4.83	21,679	22,033	87,823	4.05
1909....	7,183,644	3,259	272,493	0.038	n)13,091	13,301	54,707	4.19	18,989	18,689	83,956	4.42
1910....	8,257,474	3,745	251,716	0.031	n)16,960	17,226	48,457	2.86	14,038	14,258	65,743	4.68
1911....	5,404,263	2,451	159,626	0.030	20,860	21,195	58,726	2.82	43,222	43,916	164,301	3.80
1912....	6,758,946	3,066	246,815	0.037	26,665	27,093	79,315	2.97	26,214	26,635	95,431	3.64
1913....	6,688,216	3,034	285,537	0.043	36,875	37,490	99,564	2.97	21,456	21,814	85,746	3.99
1914....	4,079,372	1,851	165,266	0.040	25,598	26,025	77,265	3.02	24,844	25,258	96,500	3.88

Year.	Bismuth.				Chrome Ore.				Coal, Anthracite.			
	Lb.	Kg.	Value.	Value per Lb.	Long Tons.	Metric Tons.	Value.	Value per L.T.	Long Tons.	Metric Tons.	Value.	Value per L.T.
1905 .	148,589	67,459	$318,007	$2.14	54,434	55,305	$725,301	$13.32	34,262	34,810	$107,394	$3.13
1906 .	254,733	115,000	318,452	1.25	43,441	44,136	557,594	12.84	32,357	32,875	105,190	3.25
1907 .	259,881	117,882	325,015	1.25	41,999	42,671	491,925	11.71	9,896	10,054	40,966	4.14
1908 .	164,793	73,002	257,397	1.56	27,876	28,320	345,960	12.40	16,483	16,747	73,777	4.47
1909 .	183,413	83,195	286,516	1.56	39,820	40,459	460,758	11.57	4,709	4,785	19,438	4.13
1910 .	198,174	89,916	332,674	1.67	38,579	39,196	415,768	10.77	8,196	8,327	42,234	5.14
1911 .	172,093	78,061	311,771	1.81	37,529	38,131	407,958	10.87	2,463	2,502	12,550	5.10
1912 .	182,839	82,935	316,440	1.73	53,929	54,828	499,818	9.27	1,670	1,698	8,329	4.99
1913 .	117,747	53,424	213,257	1.81	65,180	66,266	627,821	9.56	921	936	5,697	6.19
1914 .	90,505	41,064	165,248	1.83	74,686	75,931	655,306	8.77	19,347	19,669	37,998	1.96

Year.	Coal, Bituminous.				Total Coal.		Coke.			
	Long Tons.	Metric Tons.	Value.	Value per L. T.	Long Tons.	Value.	Long Tons.	Metric Tons.	Value.	Value per L. T.
1905....	1,618,581	1,644,478	$3,908,877	$2.42	1,652,843	$4,016,271	181,376	184,278	$796,544	$4.39
1906....	1,712,150	1,739,544	4,129,555	2.41	1,744,507	4,234,745	114,703	116,538	558,419	4.87
1907....	2,116,122	2,149,980	5,398,167	2.55	2,126,018	5,439,133	132,536	134,656	594,137	4.48
1908....	1,487,816	1,511,621	4,059,786	2.73	1,504,299	4,133,563	129,591	131,624	603,964	4.66
1909....	1,257,629	1,277,814	3,597,991	2.56	1,262,338	3,617,429	170,671	173,410	735,253	4.31
1910....	1,991,943	2,023,914	5,381,062	2.69	2,000,270	5,423,296	156,417	158,920	625,619	4.00
1911....	1,238,808	1,258,691	3,611,518	2.92	1,241,271	3,624,068	69,515	70,631	254,938	3.67
1912....	1,608,350	1,635,156	4,509,636	2.80	1,610,020	4,517,965	110,347	112,186	488,691	4.43
1913....	1,413,857	1,437,421	3,856,811	2.73	1,414,778	3,862,508	93,507	95,065	442,687	4.73
1914....	1,375,316	1,398,238	3,889,821	2.80	1,394,663	3,927,819	120,777	122,790	555,548	4.60

Year.	Chloride of Lime.				Cement.			
	Lb.	Metric Tons.	Value.	Value per Lb.	Barrels. (c)	Metric Tons.	Value.	Value per Bbl.
1905.....	104,919,462	47,604	$843,285	$0.008	846,577	153,644	$1,102,041	$1.30
1906.....	105,221,371	47,718	863,490	0.008	2,205,712	400,115	2,950,268	1.33
1907.....	112,090,783	50,833	939,248	0.008	2,006,228	363,929	2,637,424	1.31
1908.....	74,602,059	33,848	621,713	0.008	839,246	152,313	1,189,560	1.42
1909.....	91,390,004	41,454	743,636	0.008	431,785	78,342	642,397	1.49
1910.....	101,029,345	45,839	797,260	0.008	292,314	53,053	396,428	1.36
1911.....	82,895,472	37,601	667,804	0.008	163,802	29,720	254,258	1.55
1912.....	74,235,256	33,682	597,002	0.008	65,064	11,808	93,583	1.44
1913.....	61,605,077	27,951	510,120	0.0083	77,333	14,035	134,187	1.74
1914.....	34,539,934	15,671	332,792	0.0096	115,270	20,920	193,155	1.68

Year.	Cobalt Oxide.				Copper, Ore and Matte.			
	Lb.	Kg.	Value.	Value per Lb.	Long Tons.	Metric Tons.	Value.	Value per L. T.
1905.....	70,048	31,802	$139,377	$1.99	296,251	300,991	5,765,238	$19.46
1906.....	41,084	18,652	83,167	2.02	208,702	212,041	6,796,696	32.56
1907.....	42,794	19,421	73,028	1.71	291,957	297,096	9,048,270	31.32
1908.....	1,550	701	3,095	2.00	288,022	292,630	6,978,513	24.20
1909.....	9,818	4,453	11,065	1.132	393,530	399,846	9,113,254	23.16
1910.....	6,124	2,778	4,806	0.785	453,747	461,007	9,182,161	20.23
1911.....	22,934	10,403	11,047	0.482	292,931	297,633	6,935,794	23.68
1912.....	31,848	14,446	15,132	0.475	499,549	507,875	12,696,532	25.42
1913.....	.....	.....	.....	.....	511,163	519,682	13,573,327	26.55
1914.....	227,886	103,397	220,593	0.97	417,222	424,176	12,172,138	29.17

Year.	Copper, Ingots, Old, etc.				Cryolite.			
	Lb.	Metric. Tons.	Value.	Value. per Lb.	Long Tons.	Metric Tons.	Value.	Value per L. T.
1905.....	160,619,385	72,876	$22,103,741	$0.137	1,600	1,623	$22,482	$14.05
1906.....	176,558,390	80,069	30,416,578	0.172	1,505	1,529	29,683	19.72
1907.....	192,901,267	87,523	38,658,754	0.200	1,438	1,461	28,920	20.10
1908.....	162,224,144	73,604	22,851,134	0.141	1,124	1,142	16,445	14.63
1909.....	240,713,721	109,186	30,529,425	0.127	1,278	1,299	18,427	14.42
1910.....	259,210,796	117,609	31,620,689	0.122	36	.....	2,343	.....
1911.....	265,940,760	120,630	31,540,827	0.119	2,007	2,039	47,093	23.46
1912.....	305,369,592	138,552	44,259,727	0.145	2,126	2,160	48,293	22.72
1913.....	300,068,849	136,147	44,328,574	0.148	2,559	2,602	52,557	20.54
1914.....	201,549,503	91,447	27,813,866	0.138	4,613	4,690	94,424	20.47

Year.	Emery Grains.				Emery Rock.			
	Lb.	Metric. Tons.	Value.	Value per Lb.	Long Tons.	Metric Tons.	Value.	Value per L. T.
1905....	3,209,915	1,456	$143,729	$0.045	11,073	11,250	$185,689	$16.77
1906....	4,655,168	2,113	215,357	0.043	13,840	14,061	286,386	20.69
1907....	4,282,228	1,942	186,156	0.043	11,235	11,415	211,184	18.80
1908....	1,735,366	788	89,702	0.052	8,084	8,213	146,105	18.09
1909....	2,696,960	1,224	132,264	0.049	9,836	9,993	186,930	19.00
1910....	1,189,664	535	53,709	0.045	16,770	16,321	344,421	20.54
1911....	712,134	323	35,384	0.050	10,232	10,396	176,890	17.29
1912....	791,667	359	32,876	0.042	15,793	16,052	284,585	18.01
1913....	2,496,372	1,133	114,806	0.046	17,122	17,377	342,809	20.03
1914....	761,674	346	30,017	0.039	12,662	12,873	255,554	20.10

Year.	Fuller's Earth.		Gold.		Iron Ore.			
	Long Tons.	Value.	In Coin and Bullion.	In Ore.	Long Tons.	Metric Tons.	Value.	Value per L. T.
1905...	13,001	$105,997	$38,564,328	$11,729,077	845,651	859,181	$2,062,161	$2.44
1906...	13,238	108,696	139,705,887	15,873,493	1,060,390	1,007,356	2,967,434	2.80
1907...	14,648	122,221	130,605,413	12,792,659	1,229,168	1,248,835	3,937,483	3.20
1908...	10,963	92,413	38,346,267	11,930,026	776,898	789,326	2,224,248	2.86
1909...	11,406	101,151	30,648,147	13,438,819	1,694,957	1,722,161	4,579,078	2.70
1910...	13,775	132,545	47,212,754	12,009,764	2,591,031	2,632,617	7,832,225	3.02
1911...	16,272	143,594	46,623,766	10,821,418	1,811,732	1,840,810	5,412,636	2.99
1912...	17,062	145,337	55,789,906	10,758,866	2,104,576	2,139,652	6,499,690	3.09
1913...	16,632	146,001	51,618,628	12,086,204	2,594,770	2,638,016	8,336,819	3.21
1914...	22,302	195,083	46,311,059	11,076,682	1,351,368	1,373,891	4,511,350	3.34

Year.	Phosphates, Crude.				Pig Iron.			
	Long Tons.	Metric Tons.	Value.	Value per L. T.	Long Tons.	Metric Tons.	Value.	Value per L. T.
1905....	56,021	56,917	$273,289	$4.88	212,465	215,864	$5,185,784	$24.41
1906....	23,281	23,653	147,547	6.34	379,828	385,905	11,851,210	31.20
1907....	25,876	26,290	163,944	6.34	489,475	497,305	13,418,982	27.42
1908....	26,734	27,161	175,365	6.56	92,202	93,677	2,886,339	31.35
1909....	11,903	12,094	97,277	8.18	176,442	179,265	5,112,045	28.97
1910....	19,384	19,688	235,040	12.12	237,233	241,029	6,549,938	27.61
1911....	16,153	16,412	157,394	9.74	148,459	150,842	4,380,334	29.50
1912....	28,821	29,284	231,255	8.02	129,325	131,481	4,770,730	36.89
1913....	.....	.....	.....	.....	156,450	159,058	6,557,095	41.91
1914....	15,178	15,431	136,526	9.00	138,903	141,218	4,666,668	33.60

Year.	Iron and Steel Scrap.			Bar Iron.		
	Long Tons.	Metric Tons.	Value.	Long Tons.	Metric Tons.	Value.
1905.....	23,731	24,111	$370,328	37,294	37,891	$1,522,434
1906.....	19,091	19,397	248,106	35,793	36,366	1,590,592
1907.....	27,652	28,094	368,842	39,746	40,382	1,774,441
1908.....	5,090	5,171	61,981	19,671	19,980	837,585
1909.....	63,504	64,523	781,426	19,210	19,518	806,862
1910.....	72,764	73,928	928,002	38,231	38,783	1,565,999
1911.....	17,272	17,549	190,285	26,730	27,159	1,202,363
1912.....	23,612	24,006	256,710	26,112	26,547	1,151,853
1913.....	44,154	44,890	510,707	28,243	28,714	1,340,184
1914.....	34,849	35,430	277,818	16,414	16,688	625,365

Year.	Rails.			Hoop, Band or Scroll.			Ingots, Blooms, Slabs, Billets, etc.		
	Long Tons.	Metric Tons.	Value.	Long Tons.	Metric Tons.	Value.	Long Tons.	Metric Tons.	Value.
1905...	17,278	17,554	$409,807	4,772	4,848	$137,612	(m)14,641	14,875	$2,072,606
1906...	4,943	5,022	137,104	10,231	10,395	256,836	(m)21,337	21,678	3,010,589
1907...	3,752	3,812	104,958	1,508	1,532	82,706	(m)19,334	19,643	3,004,178
1908...	1,719	1,752	53,128	1,110	1,127	75,920	11,212	11,391	1,437,514
1909...	1,542	1,567	36,963	(l)	(l)	(l)	19,289	19,599	2,695,630
1910...	(l)	(l)	(l)	(l)	(l)	(l)	46,578	47,323	4,075,036
1911...	(l)	(l)	(l)	(l)	(l)	(l)	29,205	29,687	2,772,614
1912...	3,780	3,843	101,544	(l)	(l)	(l)	18,702	19,014	2,941,481
1913...	10,408	10,581	216,272	(l)	(l)	(l)	17,765	18,061	2,651,722
1914...	22,571	22,947	610,037	648	659	23,702	(l)	(l)	(l)

Year.	Sheet, Plate and Taggers, Iron or Steel.			Tin Plates, Terne Plates and Taggers Tin.			Wire Rods.		
	Long Tons.	Metric Tons.	Value.	Long Tons.	Metric Tons.	Value.	Long Tons.	Metric Tons.	Value.
1905...	2,236	2,272	$242,955	65,740	66,792	$4,090,523	17,616	17,898	800,027
1906...	3,231	3,283	325,276	56,982	57,894	3,883,225	17,799	18,084	876,270
1907...	3,749	3,809	367,140	57,773	58,697	4,462,522	17,076	17,349	851,571
1908...	2,628	2,669	377,549	58,492	59,426	3,651,576	11,208	11,387	543,170
1909...	4,711	4,787	536,841	62,593	63,598	3,782,952	10,544	10,613	531,652
1910...	6,107	6,205	461,632	67,086	68,159	4,502,862	20,374	20,700	1,024,831
1911...	2,454	2,495	275,498	14,089	14,324	1,081,864	15,483	15,980	731,291
1912...	3,299	3,354	363,141	2,053	2,087	229,891	15,069	15,320	726,205
1913...	2,893	2,941	381,593	20,680	21,025	1,478,635	16,098	16,366	802,401
1914...	4,310	4,382	514,080	15,411	15,668	1,049,297	6,954	7,070	373,615

Year.	Wire and Articles Made from.			Total Iron Imports. (e)	Lead in Ore and Base Bullion.		
	Long Tons.	Metric Tons.	Value.		Short Tons.	Metric Tons	Value.
1905 ...	3,978	4,042	$705,465	$26,401,283	92,657	84,081	$3,565,282
1906 ...	6,610	6,716	1.079,868	34,827,132	72,371	65,640	3,490,750
1907 ...	(f)	(f)	1,551,415	38,789,992	70,538	64,019	3,579,990
1908 ...	(f)	(f)	1,003,973	19,957,385	109,315	99,168	4,384,904
1909 ...	(f)	(f)	1,117,812	30,571,542	110,605	100,339	4,121,380
1910 ...	(f)	(f)	1,468,741	47,115,112	105,117	106,805	4,056,722
1911 ...	(f)	(f)	1,270,426	28,995,600	87,319	79,215	3,452,695
1912 ...	(f)	(f)	1,103,192	29,328,709	83,288	75,576	3,721,583
1913 ...	(f)	(f)	1,167,368	33,601,985	57,105	51,817	2,962,139
1914 ...	(f)	(f)	1,205,456	28,615,344	28,190	25,580	1,867,064

Year.	Lead in Pigs and Old.			Lead, Sheet, Pipe, Shot, etc.			Other Lead Mfrs.	Total Lead.
	Short Tons.	Metric Tons.	Value.	Lb.	Metric Tons.	Value.		
1905.....	5,720	15,812	$367,160	54,779	25	$2,638	$4,580	$3,939,606
1906.....	11,763	0,669	910,417	346,177	157	17,250	20,681	4,401,167
1907.....	9,277	8,414	846,166	734,418	333	39,210	12,736	4,426,156
1908.....	2,759	2,504	182,503	42,376	19	2,026	46,486	4,567,407
1909.....	3,576	3,244	230,347	40,434	18	2,056	33,892	4,351,727
1910.....	3,491	3,166	202,376	(f)	.....	.....	7,073	4,259,098
1911.....	2,632	2,388	190,543	(f)	.....	.....	9,834	3,642,238
1912.....	272	247	19,917	31,284	14	2,305	7,328	3,748,828
1913.....	41	37	3,678	(f)	(f)	(f)	17,138	2,982,955
1914.....	148	134	10,082	(f)	(f)	(f)	83,672	1,960,818

Year.	White Lead.				Litharge.				Red Lead.			
	Lb.	Metric Tons.	Value.	Value per lb.	Lb.	Metric Tons.	Value.	Value per lb.	Lb.	Metric Tons.	Value.	Value per lb.
1905...	597,510	271	$34,722	$0.058	117,757	53	$4,139	$0.035	704,402	320	$26,553	$0.038
1906...	647,636	294	41,233	0.064	87,230	40	3,737	0.043	1,093,619	497	50,741	0.046
1907...	584,309	265	37,482	0.064	90,475	41	4,386	0.048	679,171	308	35,959	0.053
1908...	540,311	245	30,451	0.056	96,184	44	3,327	0.035	645,073	292	28,155	0.034
1909...	694,599	315	39,963	0.057	90,655	32	3,740	0.041	760,179	345	30,428	0.040
1910...	686,052	311	38,919	0.057	48,693	22	2,252	0.046	822,289	373	32,750	0.039
1911...	741,071	336	46,213	0.062	24,662	11	1,196	0.048	1,163,533	528	46,170	0.040
1912..	687,705	312	46,494	0.068	32,443	15	1,550	0.048	757,908	344	33,854	0.045
1913...	671,839	305	48,266	0.072	34,023	15	1,750	0.051	99,562	45	4,903	0.049
1914...	707,774	321	50,989	0,072	33,651	15	1,805	0.054	6,014	3	260	0.044

Year.	Orange Mineral.				Magnesite.			
	Lb.	Metric Tons.	Value.	Value per Lb.	Long Tons.	Metric Tons.	Value.	Value per L.T.
1905.....	628,003	285	$31,106	$0.049	66,405	67,566	$638,619	$9.46
1906.....	770,342	350	42,519	0.055	80,711	82,002	863,492	10.70
1907.....	615,015	279	37,793	0.061	88,400	89,814	875,359	9.90
1908.....	485,407	220	26,645	0.055	75,442	76,648	736,763	9.80
1909.....	496,231	225	27,562	0.056	102.045	103,683	985,019	9.66
1910.....	600,461	269	32,199	0.053	152,078	154,511	1,542,800	10.14
1911.....	504,734	229	28,515	0.056	120,133	122,061	1,185,867	9.85
1912.....	334,551	152	20,914	0.063	123,801	125,788	1,369,665	11.06
1913.....	330,525	150	22,205	0.067	161,012	163,696	1,757,476	10.92
1914.....	246,388	109	16,388	0.068	120,688	122,699	1,427,772	11.83

Year.	Manganese Ore.				Mica.	Nickel. (h)	Nickel Ore and Matte.		
	Long Tons.	Metric Tons.	Value.	Value per L. T.			Long Tons.	Metric Tons.	Value.
1905.....	257,033	261,146	$1,952,407	$7.60	$403,755	$335,211	13,451	13,666	$1,626,997
1906.....	221,260	224,800	1,696,043	7.67	1,042,608	86,336	15,156	15,398	1,816,671
1907.....	209,021	211,236	1,793,143	8.59	915,259	90,153	16,888	17,158	2,153,471
1908.....	178,023	181,054	1,350,223	7.59	264,755	101,398	16,322	16,582	2,206,217
1909.....	212,765	216,180	1,405,329	6.60	493,978	104,019	18,578	18,876	2,927,976
1910.....	242,348	246,226	1,711,131	7.06	721,541	139,772	28,519	28,975	4,085,059
1911.....	176,852	179,690	1,186,791	6.71	469,089	104,160	23,993	24,378	3,916,558
1912.....	300,661	305,672	1,769,184	5.84	745,399	120,511	33,101	33,653	5,638,455
1913.....	345,090	350,842	2,029,680	5.87	981,601	(f)	37,623	38,250	6,427,639
1914.....	283,294	288,016	2,024,120	5.88	204,850	(f)	29,564	30,056	4,956,448

Year.	Oil, Mineral.			Platinum, Unmanufactured.				Platinum Min.
	Gal.	Value.	Value per Gal.	Lb. Troy.	Kg.	Value.	Value per Lb. Troy.	
1905....	13,725,720	$672,127	$0.049	8,681	3,240	$1,985,107	$228.67	$188,139
1906....	21,045,316	1,061,076	0.050	13,928	5,198	3,601,021	258.54	187,859
1907....	20,505,197	1,037,728	0.051	7,515	2,805	2,509,926	333.99	175,653
1908....	9,289,376	393,050	0.042	4,155	1,551	1,096,615	263.92	134,119
1909....	3,862,445	198,540	0.051	9,904	3,696	2,557,574	258.30	410,967
1910....	24,323,829	1,438,609	0.059	10,009	3,736	3,320,699	331.77	1,717,584
1911....	69,019,304	2,406,581	0.035	2,868	1,070	1,278,293	445.71	3,587,206
1912....	309,765,930	6,033,231	0.019	3,692	1,378	1,716,630	464.96	2,777,833
1913....	731,360,523	12,997,011	0.018	4,283	1,599	1,978,770	462.01	3,065,469
1914....	724,446,909	11,500,730	0.016	2,676	999	1,154,955	431.60	1,815,668

Year.	Potassium Salts.											
	Chlorate.			Chloride.			Chromate and Bichromate.			Nitrate.		
	Lb.	Value.	Value per Lb.	Lb.	Value.	Value per Lb.	Lb.	Value.	Value per Lb.	Lb.	Value.	Value per Lb.
		$	$		$	$		$	$		$	$
1905....	42,510	2,876	0.067	214,207,064	3,326,748	0.016	59,650	4,225	0.070	9,911,534	304,596	0.027
1906....	45,873	3,103	0.068	223,203,387	3,858,895	0.017	30,098	2,102	0.080	11,326,256	371,595	0.033
1907....	12,980	959	0.074	252,303,441	4,175,353	0.017	18,171	1,307	0.072	18,291,890	574,977	0.031
1908....	17,607	1,447	0.082	214,338,887	3,415,326	0.016	216,080	15,453	0.072	16,118,160	470,116	0.029
1909....	22,425	1,837	0.082	298,854,649	4,780,106	0.016	640,623	31,798	0.050	14,883,849	437,690	0.029
1910....	410,770	26,313	0.064	381,873,875	5,252,373	0.014	406,791	19,569	0.048	11,496,904	333,854	0.029
1911....	27,856	2,450	0.088	509,119,193	7,651,684	0.015	22,408	2,159	0.096	7,945,747	265,061	0.033
1912....	99,919	6,787	0.068	482,265,665	7,229,109	0.015	32,913	3,085	0.094	7,315,531	216,492	0.030
1913....	1,191,461	64,468	0.054	478,826,857	7,120,055	0.015	18,629	1,819	0.097	9,876,910	262,575	0.027
1914....	27,406	2,235	0.083	371,520,195	5,745,385	0.015	31,858	2,375	0.075	2,229,856	74,743	0.034

Year	Potassium Salts, All Other. (a)		Precious Stones.			Pyrite. (i)			
	Lb.	Value.	Uncut.	Cut, not Set.	Jewelry.	Long Tons.	Metric Tons.	Value.	Value per L. T.
1905.	82,935,632	$1,891,081	$10,206,350	26,699,670	$801,566	515,722	520,926	$1,780,800	$3.47
1906.	30,302,735	763,513	11,937,542	$32,201,949	988,766	597,347	606,903	2,138,746	3.58
1907.	91,299,496	2,220,685	8,740,278	23,706,975	1,069,373	656,479	666,981	2,637,485	4.01
1908.	69,382,278	1,721,626	2,367,189	11,660,442	720,502	668,115	678,804	2,624,339	3.93
1909.	100,180,417	2,445,526	9,230,287	34,340,269	1,267,457	692,385	703,498	2,428,638	3.51
1910.	116,820,873	2,777,396	9,426,647	32,424,471	1,907,148	806,590	819,495	2,773,627	3.45
1911.	155,140,643	3,909,361	9,963,393	30,224,826	1,470,167	1,001,944	1,018,025	3,788,632	3.78
1912.	131,049.932	3,185,098	9,979,582	26,218,261	989,288	964,478	980,553	3,860,738	3.99
1913.	124,519,551	3,253,245	12,630,037	27,626,937	998,723	848,674	862,819	3,611,136	4.00
1914.	.....	.....	3,008,823	13,652,861	775,364	977,372	993,662	4,706,383	4.32

Year.	Salt.				Silver.		Sodium Nitrate.			
	Short Tons.	Metric Tons.	Value.	Value per Sh. T.	In Coin and Bullion.	In Ore.	Long Tons.	Metric Tons.	Value.	Value per L. T.
1905..	158,449	143,783	$491,079	$3.10	$16,472,911	$19,466,224	321,231	326,371	$11,206,548	$34.89
1906..	170,505	154,648	502,583	2.95	20,402,738	23,825,103	372,222	378,178	14,115,206	37.92
1907..	153,435	139,166	452,227	2.95	17,652,679	28,259,681	364,610	370,444	14,844,675	40.71
1908..	156,608	142,043	440,484	2.81	14,169,524	28,054,606	310,713	315,684	11,385,393	36.68
1909..	158,487	143,777	447,983	2.83	15,728,756	30,458,946	428,429	435,569	13,608,195	31.43
1910..	142,549	129,320	388,015	2.72	15,913,668	29,964,500	529,172	605,938	16,601,328	31.37
1911..	137,759	124,974	378,083	2.74	16,351,154	27,395,417	544,878	553,623	16,814,256	30.86
1912..	136,391	123,762	361,664	2.65	24,053,983	24,347,103	486,352	494,458	16,554,104	34.04
1913..	150,602	136,609	416,375	2.77	19,979,971	15,887,848	625,862	636,293	21,630,811	34.56
1914..	132,970	120,656	385,752	2.90	18,941,980	7,017,207	543,715	552,777	15,228,671	28.01

Year.	Sodium Hydroxide (Caustic).			Soda Ash and Carbonate.			All other Sodium Salts.	
	Lb.	Value.	Value. per Lb.	Lb.	Value.	Value per Lb.	Lb.	Value.
1905..	2,245,789	$56,515	$0.025	15,754,979	$146,812	$0.009	11,257,629	$247,413
1906..	1,209,053	35,262	0.022	6,800,288	71,013	0.010	.....	.....
1907..	1,297,070	37,894	0.029	6,198,136	66,521	0.011	8,481,979	258,262
1908..	874,813	26,079	0.029	3,515,933	38,372	0.011	.....	296,777
1909..	942,982	29,771	0.032	153,928	3,543	0.023	13,805,869	350,396
1910..	2,973,522	70,901	0.027	314,396	4,269	0.014	35,895,668	406,643
1911..	990,562	34,281	0.035	3,214,129	36,252	0.011	22,202,439	303,934
1912..	884,204	29,461	0.033	3,393,354	39,912	0.012	7,332,392	232,808
1913..	696,158	25,888	0.037	2,962,180	35,872	0.012	7,518,125	263,162
1914..	535,883	21,607	0.040	3,130,366	51,869	0.017	.....	.....

Year.	Sulphur.									
	Crude.				Flowers.			Refined.		
	Long Tons.	Metric Tons.	Value.	Value per L. T.	Long Tons.	Metric Tons.	Value.	Long Tons.	Metric Tons.	Value.
1905..	83,201	84,532	$1,522,005	$18.29	572	581	$16,037	778	709	$19,960
1906..	72,404	73,562	1,282,873	17.72	1,100	1,118	29,565	709	720	17,928
1907..	20,399	20,725	355,944	17.45	1,458	1,481	41,216	606	616	14,589
1908..	20,118	20,441	318,577	15.83	793	804	22,562	692	700	17,227
1909..	26,914	27,346	458,954	17.05	770	782	23,084	966	982	26,021
1910..	28,647	29,105	495,988	17.31	915	930	30,180	990	1,004	25,869
1911..	24,250	24,639	436,725	18.01	3,891	3,953	83,491	986	1,002	24,906
1912..	26,885	27,333	494,778	18.40	1,310	1,331	39,126	1,665	1,692	40,933
1913..	14,636	14,880	278,056	19.00	5,899	5,997	115,574	1,233	1,254	29,091
1914..	22,810	23,190	409,537	18.39	621	631	17,214	1,800	1,830	47,568

Year.	Talc.				Tin.			
	Short Tons.	Metric Tons.	Value.	Value per Sh. T.	Lb.	Metric Tons.	Value.	Value per Lb.
1905...	4,000	3,630	$48,225	$12.06	89,227,698	40,507	$26,316,023	$0.294
1906...	5,643	5,118	67,818	12.02	101,027,188	45,816	37,446,508	0.371
1907...	10,060	10,221	126,391	12.56	82,548,838	37,436	32,075,091	0.389
1908...	7,429	6,738	97,296	13.08	82,503,190	37,433	23,932,560	0.290
1909...	8,377	7,599	102,964	12.29	95,350,020	43,250	27,559,937	0.289
1910...	8,378	7,560	106,451	12.72	105,137,740	47,703	33,921,449	0.322
1911...	7,113	6,453	88,050	12.38	106,936,872	48,506	43,390,639	0.406
1912...	10,817	9,813	121,541	11.24	116,003,385	52,633	50,371,102	0.434
1913...	14,004	12,702	143,500	10.25	104,282,230	47,315	46,900,314	0.450
1914...	17,869	16,210	202,415	11.33	95,049,612	43,126	32,861,188	0.346

Year.	Zinc.								Mfrs.
	Blocks, Pigs and Old.				Oxide. (j)		Sulphide.		
	Lb.	Metric Tons.	Value.	Value, per Lb.	Lb.	Value.	Lb.	Value.	Value.
1905	1,042,081	473	$51,052	0.048	3,779,311	$196,220	1,235,360	$33,308	$12,390
1906	4,407,481	1,999	253,310	0.057	4,494,014	288,065	1,286,469	40,112	17,385
1907	3,555,890	1,613	210,322	0.059	5,311,318	323,551	1,570,073	51,435	16,282
1908	1,762,627	799	85,885	0.049	4,635,101	262,876	1,048,109	46,733	7,474
1909	19,340,029	8,772	826,588	0.043	6,654,352	397,084	1,263,316	44,873	19,176
1910	6,904,389	3,133	289,689	0.042	6,470,097	391,670	3,726,135	99,954	27,475
1911	3,275,340	1,486	170,634	0.052	5,561,016	357,466	6,355,312	166,199	124,983
1912	22,229,831	10,086	1,280,426	0.058	5,875,057	386,153	5,904,475	153,303	293,089
1913	12,199,267	5,535	660,706	0.054	6,865,094	433,886	5,066,535	152,980	62,256
1914	1,759,579	798	71,165	0.040	5,258,108	302,838	9,072,567	277,862	31,724

(a) From Summary of Commerce and Finance of the United States. (b) Includes arsenic sulphide. (c) Barrels of 400 lb. (e) Not including iron ore. (f) Not reported. (h) Includes nickel oxide, alloys in which nickel is the principal constituent, and manufactures of nickel. (i) Containing more than 25 per cent. sulphur. (j) Includes white pigments containing zinc but not lead, dry and in oil. (m) Includes bars of steel and steel forms not elsewhere specified. The high value is due to the value of "high-speed" steel. (n) Crude. (o) Crude, scrap and alloys in which aluminum is chief component. (r) Antimony contents of ores, regulus and metal. (s) Not kainit.

EXPORTS OF DOMESTIC PRODUCTS (a)

Year.	Aluminium and Mfrs. of.	Asbestos and Mfrs. of.	Cement.			
			Bbl.(i)	Metric Tons.	Value.	Value per Bbl.
1905	$ 290,777	.....	1,016,236	185,345	$1,387,706	$1.37
1906	364,251	$259,760	583,299	105,811	944,886	1.62
1907	304,938	200,371	900,550	163,360	1,450,841	1.61
1908	330,092	296,890	846,785	153,638	1,249,229	1.47
1909	567,375	322,523	1,056,922	191,764	1,417,534	1.34
1910	949,215	348,716	2,475,957	449,314	3,477,981	1.40
1911	1,158,603	448,395	3,135,409	568,886	4,632,215	1.48
1912	1,347,621	601,701	4,215,532	765,069	6,160,341	1.46
1913	966,094	754,102	2,964,358	538,041	4,270,666	1.44
1914	1,546,510	513,037	2,140,497	388,475	3,088,809	1.44

Year	Coal.									
	Anthracite.				Bituminous.				Coke.	
	Long Tons.	Metric Tons.	Value.	Value per L. T.	Long Tons.	Metric Tons.	Value.	Value per L.T.	Long Tons.	Value.
1905	2,229,983	2,265,663	$11,104,654	$4.98	6,959,265	7,070,613	$17,867,964	$2.56	599,054	$2,243,011
1906	2,216,969	2,252,441	10,896,200	4.91	7,704,850	7,828,128	19,787,459	2.57	765,190	2,753,550
1907	2,698,072	2,741,241	13,217,985	4.90	(m)10,454,677	10,621,950	(m)26,982,111	2.54	874,689	3,206,791
1908	2,752,358	2,796,394	13,524,595	4.92	(m) 9,100,819	9,246,431	(m)23,361,914	2.53	620,923	2,161,032
1909	2,842,714	2,888,340	14,141,468	4.97	(m) 9,693,843	9,849,429	(m)24,300,050	2.51	895,461	3,232,673
1910	3,021,627	3,070,124	14,785,387	4.89	(m)10,784,239	10,957,326	(m)26,685,405	2.47	879,073	3,053,293
1911	3,553,999	3,611,041	18,093,285	5.09	(m)13,878,754	14,101,508	(m)34,499,989	2.49	914,042	3,215,490
1912	3,688,789	3,750,268	19,425,263	5.27	(m)14,459,978	14,700,978	(m)36,817,633	2.55	814,800	3,002,742
1913	4,154,386	4,224,625	21,959,850	5.29	(m)17,986,757	18,286,536	(m)45,449,664	2.53	881,603	3,309,930
1914	3,830,244	3,894,081	20,211,072	5.28	(m)13,801,850	14,031,881	(m)34,104,903	2.47	592,487	2,233,686

Year.	Copper.									
	In Ore and Matte.				Ingots, Bars, Plates and Old.				Mfrs.	Total, Except Ore.
	Long Tons.	Metric Tons.	Value.	Value per L. T.	Lb.	Metric Tons.	Value.	Value per Lb.	Value.	
1905	37,688	38,291	$1,531,429	$40.63	534,907,619	242,699	$80,693,232	$0.151	$4,184,070	$84,890,302
1906	47,619	48,380	1,760,140	36.96	454,752,018	206,239	84,728,400	0.186	4,284,611	89,013,011
1907	99,141	100,727	2,452,562	24.74	508,929,401	230,799	94,912,185	0.186	5,888,170	100,800,355
1908	63,149	64,158	1,254,172	19.87	661,876,127	300,302	87,393,200	0.132	3,162,303	90,555,503
1909	59,880	60,841	1,335,316	22.29	682,846,726	309,734	89,367,455	0.131	3,217,185	92,584,640
1910	43,784	44,585	1,049,086	23.96	695,107,043	315,384	88,949,799	0.128	5,132,287	94,082,086
1911	57,915	58,844	2,352,080	40.61	786,553,208	356,778	98,168,182	0.122	5,159,664	103,327,346
1912	66,171	67,274	3,203,220	48.41	775,000,658	351,634	123,007,884	0.159	3,762,283	126,770,167
1913	65,684	66,779	2,973,997	45.28	926,241,092	420,255	143,353,624	0.155	1,555,493	144,909,117
1914	43,529	44,254	1,606,855	36.91	840,080,922	381,162	116,026,290	0.138	1,162,060	117,188,350

Year.	Gold.		Iron.							
			Ore.				Pig.			
	In Coin and Bullion. (c)	In Ore. (d)	Long Tons.	Metric Tons.	Value.	Value per L.T.	Long Tons.	Metric Tons.	Value.	Value per L. T.
1905.....	$46,099,580	$694,887	208,017	211,345	$530,457	$2.55	49,221	50,009	$762,899	$15.50
1906.....	46,068,451	640,707	265,240	269,484	771,831	2.91	83,317	84,650	1,506,774	18.08
1907.....	54,869,688	345,993	278,208	282,659	763,422	2.74	73,703	74,879	1,508,938	20.43
1908	80,778,091	437,365	309,099	314,043	1,012,924	3.29	46,696	47,441	789,318	16.92
1909.....	132,349,610	540,211	455,934	463,251	1,365,325	2.99	61,989	62,994	1,030,267	16.66
1910.....	54,968,487	470,062	644,875	655,193	2,074,164	3.22	127,385	129,423	2,113,036	16.51
1911.....	34,488,840	499,265	768,386	780,719	2,653,448	3.45	120,799	122,738	1,874,401	15.52
1912.....	43,921,951	470,333	1,195,742	1,215,671	3,537,289	2.96	272,676	277,221	3,832,765	13.84
1913.....	88,331,790	602,781	1,042,151	1,059,520	3,513,419	3.37	277,648	282,275	4,026,306	14.50
1914.....	220,409,005	285,038	551,618	560,812	1,794,193	3.20	114,423	116,330	1,638,102	14.32

Year.	Iron, Bar.				Iron, Band, Hoop and Scroll.			Billets, Ingots and Blooms.			
	Long Tons.	Metric Tons.	Value.	Value per L. T.	Long Tons.	Metric Tons.	Value.	Long Tons.	Metric Tons.	Value.	Value per L. T.
1905.....	32,025	32,537	$1,255,418	$39.20	4,426	4,497	$ 182,431	237,738	241,542	$4,701,909	$19.79
1906.....	56,024	56,920	2,575,905	45.98	5,405	5,491	242,776	192,616	195,698	4,094,659	21.26
1907.....	24,190	24,577	1,092,631	45.17	8,587	8,724	395,758	79,991	81,271	2,013,319	25.17
1908.....	8,224	8,355	362,909	44.12	4,334	4,402	223,073	112,177	113,390	2,674,524	23.84
1909.....	13,536	13,755	538,436	39.77	3,856	3,918	200,379	104,862	106,545	2,401,091	22.90
1910.....	18,045	18,234	726,300	40.25	(n)	(n)	(n)	58,230	59,162	1,274,732	21.89
1911.....	17,683	17,967	653,320	36.94	3,731	3,791	163,853	234,267	238,027	5,150,518	21.99
1912.....	21,926	22,291	841,824	38.39	12,557	12,766	539,354	294,818	299,732	6,615,131	22.44
1913.....	16,615	16,892	768,501	46.25	16,841	17,122	767,631	91,847	93,378	2,200,248	23.96
1914.....	5,226	5,313	203,835	39.00	9,954	10,120	457,451	50,496	51,338	1,103,702	21.86

Year.	Iron, Nails and Spikes, Cut.				Iron, Nails and Spikes, All Other.				Iron, Plates and Sheets.		
	Lb.	Metric Tons.	Value	Value per Lb.	Lb.	Metric Tons.	Value.	Value per Lb.	Long Tons.	Met. Tons.	Value.
1905	17,674,099	8,019	$352,405	$0.020	89,976,088	40,506	$2,118,836	$0.024	8,004	8,132	$460,995
1906	16,951,893	7,688	340,526	0.020	116,310,428	52,747	2,731,021	0.024	17,054	17,327	1,139,526
1907	15,521,208	7,042	354,802	0.023	111,670,147	50,642	3,014,863	0.027	40,651	41,301	2,902,025
1908	15,721,898	7,133	364,202	0.023	71,427,124	32,407	1,813,784	0.025	44,100	44,805	2,985,538
1909	22,256,458	10,095	456,635	0.021	85,387,006	38,731	1,993,142	0.023	75,305	76,513	4,706,592
1910	18,208,116	8,261	361,838	0.020	118,881,375	53,939	2,693,753	0.023	102,534	104,175	6,412,458
1911	25,585,379	11,605	470,515	0.018	148,875,384	67,529	3,279,105	0.022	134,497	137,113	8,353,089
1912	20,856,790	9,463	359,962	0.017	186,646,470	84,685	3,976,571	0.021	193,719	196,948	11,844,767
1913	8,488,503	3,851	165,068	0.019	132,014,432	59,898	3,031,967	0.023	98,978	100,628	6,568,413
1914	7,667,552	3,479	142,285	0.019	103,485,214	46,953	2,264,031	0.022	48,818	48,018	3,128,184

Year.	Steel, Sheets and Plates.			Iron Rails.				Steel Rails.			
	Long Tons.	Metric Tons.	Value.	Long Tons.	Metric Tons.	Value.	Value per L. T.	Long Tons.	Metric Tons.	Value.	Value per L. T.
1905 ..	67,093	68,166	$2,889,084	*Nil.*	.....	.....	.....	295,023	299,473	$7,310,029	$24.78
1906 ..	93,601	95,099	4,081,915	*Nil.*	.....	.....	.....	328,036	333,285	8,903,411	27.14
1907 ..	82,045	83,358	4,262,582	*Nil.*	.....	.....	.....	338,906	344,328	10,411,072	30.72
1908 ..	60,893	61,865	3,422,031	*Nil.*	.....	.....	.....	196,510	199,654	6,021,549	30.62
1909 ..	104,742	106,423	4,627,614	*Nil.*	.....	.....	.....	299,540	304,533	8,519,793	28.44
1910 ..	171,982	174,734	7,514,832	*Nil.*	.....	.....	.....	353,180	358,831	10,162,522	28.77
1911 ..	237,428	241,239	9,800,215	*Nil.*	.....	.....	.....	420,874	427,629	12,229,045	29.05
1912 .	352,802	358,682	14,508,622	*Nil.*	.....	.....	.....	446,473	453,914	13,053,774	29.24
1913 ..	364,448	370,522	14,472.711	*Nil.*	.....	.....	.....	460,553	468,229	13,979,549	30.35
1914 ..	232,078	235,946	9,308,312	*Nil.*	.....	.....	.....	174,680	177,591	5,103,918	29.22

Year.	Structural Iron and Steel.				Wire.				Steel Wire Rods.			
	Long Tons.	Metric Tons.	Value.	Value per L.T.	Long Tons.	Metric Tons.	Value.	Value per L. T.	Long Tons.	Metric Tons.	Value.	Value per L. T.
1905	84,234	85,582	$4,357,186	$51.73	142,601	144,883	$7,061,442	$49.52	6,514	6,618	$277,651	42.62
906	112,555	114,356	6,140,861	54.56	174,014	176,798	8,770,042	50.40	5,896	5,990	221,679	37.60
1907	138,442	140,657	7,784,618	56.23	161,228	163,808	9,164,829	56.84	10,653	10,823	465,757	43.72
1908	116,878	118,746	6,289,610	53.80	136,167	138,344	7,270,794	53.35	7,412	7,530	277,694	37.39
1909	90,830	92,288	4,488,197	49.42	149,341	151,738	7,836,564	52.49	20,142	20,465	635,409	31.56
1910	146,721	149,069	7,127,673	48.58	171,928	174,679	9,198,005	53.49	22,869	23,235	714,553	31.25
1911	223,493	227,080	10,270,977	45.96	229,762	233,452	11,637,596	50.65	22,641	23,003	659,066	29.10
1912	288,164	292,967	12,694,804	44.05	244,711	248,790	11,536,442	47.14	64,978	66,061	1,898,986	29.22
1913	403,264	409,985	17,790,744	44.12	190,284	193,455	9,237,541	48.55	61,637	62,664	1,815,922	29.46
1914	182,395	185,435	6,961,636	38.17	180,842	183,856	8,568,589	47.38	61,856	62,887	1,810,389	29.27

Year.	Lead and Mfrs. of.	Nickel. (e)	Petroleum products. (In Thousands of Units.)*								
			Crude.			Naphtha.			Illuminating Oil.		
			M Gals.	M Value.	Value per Gal.	M Gals.	M Value.	Value per Gal.	M Gals.	M Value.	Value per Gal.
1905	$511,699	$2,894,700	126,185	$6,086	$0.048	28,420	$2,215	$0.078	881,450	$54,901	$0.062
1906	600,057	3,493,643	148,045	7,731	0.052	27,545	2,488	0.090	878,284	54,858	0.063
1907	686,096	2,845,663	126,306	6,334	0.050	34,625	3,676	0.106	905,924	59,635	0.066
1908	599,640	3,297,988	149,190	6,520	0.044	43,887	4,543	0.103	1,129,005	75,988	0.067
1909	509,542	4,101,976	186,305	6,568	0.035	68,759	5,800	0.084	1,046,401	67,814	0.065
1910	614,158	4,704,088	180,111	5,404	0.029	100,695	8,407	0.083	940,247	55,642	0.059
1911	680,419	8,283,777	201,843	6,165	0.030	137,295	11,483	0.084	1,112,295	61,055	0.055
1912	651,459	8,515,332	188,711	6,770	0.036	186,000	20,459	0.110	1,026,138	62,084	0.061
1913	738,135	9,686,794	194,570	8,448	0.043	188,043	28,092	0.149	1,119,441	72,042	0.064
1914	5,519,908	9,455,528	124,736	4,959	0.040	209,693	25,288	0.121	1,010,449	64,113	0.063

Year.	Petroleum Products. (In Thousands of Units.)*									
	Lubricating Oil.			Residue, Etc. (g)			Paraffin.			
	M Gals.	M Value.	Value per Gal.	M Gals.	M Value.	Value per Gal.	M Lb.	M Metric Tons.	M Value.	Value per Lb.
1905	113,730	$14,312	$0.126	70,728	$2,128	$0.030	160,836	$73.0	$7,873	$0.049
1906	151,269	18,690	0.124	64,645	1,971	0.030	173,504	72.9	8,463	0.049
1907	152,029	19,210	0.126	75,775	2,528	0.033	207,504	94.1	10,209	0.049
1908	147,769	18,971	0.128	77,552	2,793	0.036	141,667	64.2	6,923	0.049
1909	161,640	20,076	0.124	107,999	3,640	0.034	181,328	82.6	7,609	0.042
1910	163,832	20,291	0.125	117,605	3,732	0.032	199,913	90.7	7,329	0.037
1911	183,320	23,337	0.127	133,979	3,882	0.029	214,018	97.1	7,048	0.033
1912	216,393	28,297	0.131	266,237	6,599	0.025	294,591	133.7	9,603	0.033
1913	207,639	29,609	0.143	426,872	11,126	0.026	236,046	107.1	8,177	0.035
1914	191,648	26,316	0.137	703,507	19,224	0.027	188,823	85.7	6,435	0.034

* For convenience in tabulating, the quantities of all petroleum products and their gross values have been divided by 1000.

Year.	Crude Phosphates.				Quicksilver.			Silver.	
	Long Tons.	Metric Tons.	Value.	Value per L.T.	Lb.	Metric Tons.	Value.	In Coin and Bullion (c)	In Ore (d)
1905	934,940	949,899	$7,465,592	$7.91	1,009,446	458	$497,470	$54,133,721	$3,379,391
1906	904,214	918,681	7,373,945	8.16	484,151	219	243,914	57,012,104	266,674
1907	1,018,212	1,034,503	8,387,176	8.24	384,913	174	192,094	61,202,024	423,842
1908	1,196,175	1,215,374	9,371,649	7.83	224,692	102	124,960	51,554,414	283,237
1909	1,020,556	1,036,936	7,644,368	7.49	510,241	231	266,243	56,876,292	716,017
1910	1,083,037	1,100,366	8,234,276	7.63	144,237	65	91,077	53,298,048	346,735
1911	1,246,577	1,266,585	9,235,388	7.41	21,841	10	13,995	59,756,121	129,909
1912	1,206,520	1,226,629	8,996,456	7.46	23,283	11	13,360	66,846,486	137,752
1913	1,366,508	1,389,283	9,996,580	7.32	85,521	39	43,574	59,509,520	154,789
1914	964,114	980,183	6,771,652	7.02	108,426	49	70,753	47,767,578	76,084

Year.	Zinc Ore.				Zinc, Pigs, Bars, Plates and Sheet.			
	Long. Tons.	Metric Tons.	Value.	Value Per L.T.	Lb.	Metric Tons.	Value.	Value. per Lb.
1905.....	27,630	28,072	$848,451	$30.71	11,031,815	5,005	$682,254	$0.062
1906.....	24,750	25,146	733,300	29.63	9,340,455	4,236	583,526	0.062
1907.....	18,171	18,462	579,490	31.89	1,126,753	511	75,194	0.067
1908.....	23,311	23,683	877,745	37.61	5,280,344	2,396	250,254	0.047
1909.....	11,121	11,299	412,300	37.01	5,131,360	2,328	263,010	0.051
1910.....	17,599	17,881	649,425	36.90	7,979,457	3,620	426,500	0.053
1911.....	16,322	16,584	642,884	39.39	13,744,212	6,234	810,099	0.059
1912.....	20,847	21,194	823,997	39.53	13,268,186	6,020	864,292	0.065
1913.....	15,815	16,079	631,991	40.00	15,565,324	7,062	955,667	0.061
1914.....	9,920	10,085	388,464	39.06	129,604,022	58,804	8,540,668	0.066

Year.	Zinc Oxide.			
	Lb.	Metric Tons.	Value.	Value per Lb.
1905.....	22,559,625	10,236	$810,203	$0.036
1906.....	31,156,616	14,129	1,149,297	0.037
1907.....	26,512,920	12,023	1,060,924	0.040
1908.....	24,016,254	10,893	845,070	0.035
1909.....	26,691,347	13,468	1,026,377	0.035
1910.....	26,333,993	11,949	943,968	0.036
1911.....	29,236,779	13,262	1,051,311	0.036
1912.....	34,128,163	15 484	1,247,702	0.037
1913.....	28,932,953	13,127	1,136,257	0.039
1914.....	31,183,369	14,148	1,408,525	0.045

RE-EXPORTS OF FOREIGN PRODUCTS (a)

Year.	Antimony.			Antimony Ore.			Asphaltum, Crude.		
	Lb.	Metric Tons.	Value.	Short Tons.	Metric Tons.	Value.	Long Tons.	Metric Tons.	Value.
1905.....	*Nil.*	.....	.....	*Nil.*	.....	.....	1,081	1,098	$18,190
1906.....	24,892	11.2	$4,939	*Nil.*	.....	.....	1,765	1,793	22,324
1907.....	47,999	21.8	9,064	6	5	$273	8,288	8,421	31,749
1908.....	1,763	0.8	125	4.8	4.3	663	4,262	4,290	21,419
1909.....	6,648	3.0	475	0.25	0.23	56	6,867	6,977	48,375
1910.....	339,685	154.1	20,392	*Nil.*	.....	.....	5,830	5,948	29,942
1911.....	160,844	73.0	9,737	*Nil.*	.....	.....	3,402	3,457	48,552
1912.....	(o)50,684	23.0	2,766	*Nil.*	.....	.....	2,589	2,632	62,276
1913.....	63,620	29.0	4,365	0.18	0.16	22	1,282	1,303	25,954
1914.....	.....	.....	.....	800	727	211,742	21	21	387

Year.	Cement.			Chemicals.					
	Bbl. (i)	Metric Tons.	Value.	Salts of Potassium. (f)			Chloride of Lime.		
				Lb.	Kg.	Value.	Lb.	Kg.	Value.
1905...	31,874	5,782	$40,583	3,053,191	1,386,149	$83,652	100	102	$ 3
1906...	16,216	2,941	19,487	2,264,175	1,027,935	77,043	*Nil.*	.....	.....
1907...	20,697	3,754	30,435	2,675,248	1,285,892	75,470	*Nil.*	.....	.....
1908...	9,552	1,734	11,455	1,046,689	570,445	34,505	121,511	55,116	912
1909...	4,198	762	6,312	2,332,386	1,058,251	66,352	13,964	6,334	292
1910...	17,914	3,251	24,878	2,187,787	922,645	60,648	496	225	6
1911...	8,529	1,547	14,095	2,731,792	1,239,133	67,297	17,804	8,076	241
1912...	4,356	791	8,419	4,932,143	2,237,814	103,425	400	181	8
1913...	2,553	460	4,075	8,660,837	3,929,599	162,467	13,260	6,016	333
1914...	719	130	1,038	8,760,640	3,974,882	204,423	15,990	7,255	291

Year.	Chemicals. (*Continued.*)											
	Nitrate of Sodium.			Caustic Soda.			Soda Ash and Carbonate.			Sodium Salts, All Other.		
	Long Tons.	Metric Tons.	Value.	Lb.	Kg.	Value.	Lb.	Kg.	Value.	Lb.	Kg.	Value.
1905..	8,991	9,135	$420,613	1,087,772	493,848	$22,728	32,221	14,628	$473	16,748	7,604	$177
1906..	6,660	6,767	324,915	(1)	.....	.....	2,486	1,128	41	1,032,372	468,180	21,624
1907..	7,159	7,274	370,048	(1)	.....	.....	3,100	1,406	53	742,201	336,662	16,099
1908..	9,955	10,113	514,799	(1)	.....	.....	4,645	2,104	77	834,207	378,726	18,255
1909..	8,233	8,365	377,571	(1)	.....	.....	(1)	.....	....	1,053,410	477,816	21,777
1910..	5,784	5,878	250,550	(1)	.....	.....	(1)	.....	....	333,427	151,282	11,767
1911..	6,787	6,896	269,274	(1)	.....	.....	(1)	.....	....	611,922	277,566	14,479
1912..	8,853	8,995	440,200	(1)	.....	.....	(1)	.....	....	431,407	195,685	9,416
1913..	5,560	5,653	295,111	(1)	.....	.....	(1)	.....	....	534,470	242,500	12,672
1914..	9,220	9,374	460,868	.....	.....	.....	.....	.....	....	.....	.....	13,654

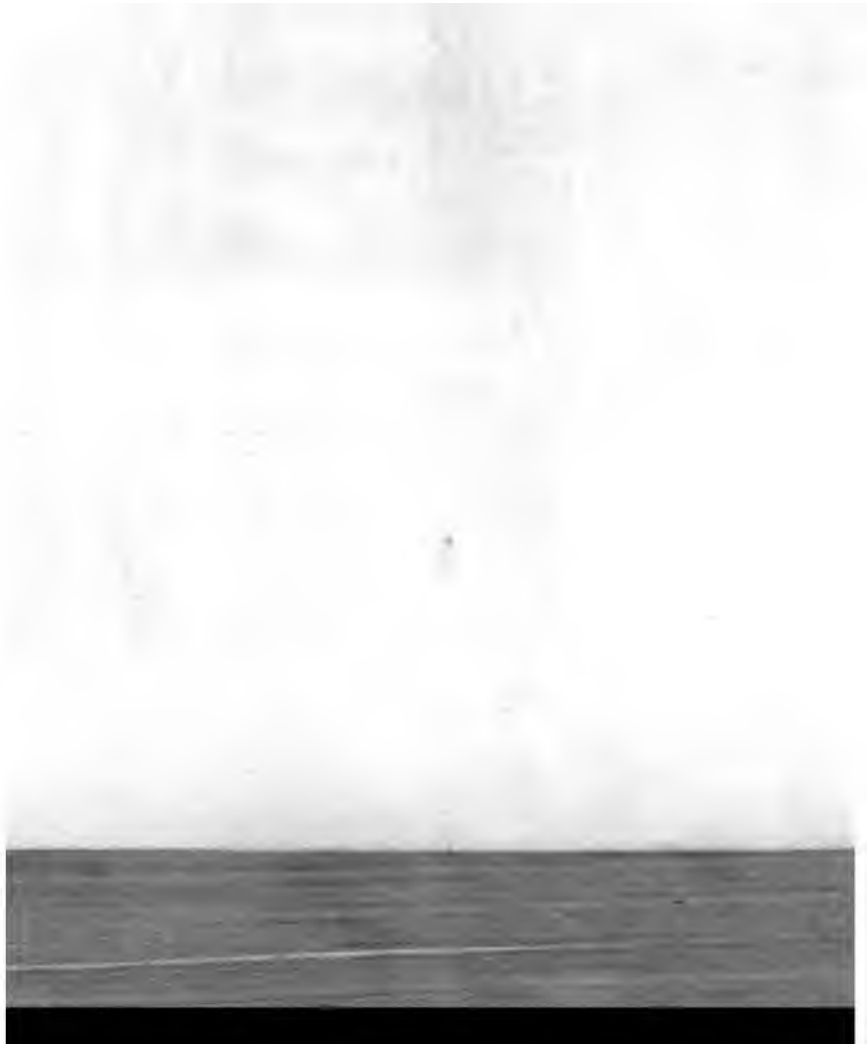
Year.	Coal, Bituminous.			Copper.						Graphite.	
				Ore and Matte.			Pigs, Bars, Ingots, Old, and All Unmanufactured.				
	Long. Tons.	Metric Tons.	Value.	Long Tons.	Metric Tons.	Value.	Lb.	Metric Tons.	Value.	Long Tons.	Value.
1905....	3,945	4,008	$10,974	*Nil.*	....	.....	1,718,584	780	$272,945	5	$81
1906....	2,541	2,582	13,062	71	....	.....	1,567,782	711	309,605	3	382
1907....	1,947	1,978	12,199	....	72	$ 29,791	995,555	451	199,828	1	41
1908....	4,759	4,832	16,313	2	....	.....	718,541	326	93,148	....	.....
1909....	3,128	3,178	8,532	434	2	50	1,058,528	480	135,952	16	976
1910....	3,734	3,894	13,761	*Nil.*	441	5,600	55,857	25	6,443	34	3,192
1911....	3,718	3,778	10,296	*Nil.*	....	.....	200	0.1	52	*Nil.*	.....
1912....	982	998	6,574	*Nil.*	....	.....	1,020	0.5	132	*Nil.*	.....
1913....	1,179	1,199	6,652	*Nil.*	....	.....	557	0.3	135	1	66
1914....	21,390	21,747	118,241	*Nil.*	....	.....	3,436	1.6	534	*Nil.*	.....

Year.	Iron and Steel.											
	Pig Iron.			Scrap.			Bar Iron.			Rails.		
	Long Tons.	Metric Tons.	Value.	Long Tons.	Metric Tons.	Value.	Long Tons.	Metric Tons.	Value.	Long Tons.	Metric Tons.	Value.
1905.....	1,010	1,026	$29,047	4,270	4,338	$80,623	22	22	$2,556	31	31	$1,132
1906.....	6,750	6,858	236,957	5,111	5,193	101,886	61	62	7,207	*Nil.*	....	.....
1907.....	2,921	2,968	86,420	157	160	3,378	38	39	3,959	*Nil.*	....	.....
1908.....	1,827	1,855	52,079	288	293	3,597	26	26	1,271	*Nil.*	....	.....
1909.....	720	732	25,936	....	....	.....	20	20	1,500	*Nil.*	....	.....
1910.....	579	588	20,706	....	....	.....	9	9	356	*Nil.*	....	.....
1911.....	1,837	1,866	73,987	100	102	1,373	12	12	635	*Nil.*	....	.....
1912.....	5,087	5,169	130,102	198	201	3,788	25	25	1,176	*Nil.*	....	.....
1913.....	765	778	29,257	70	71	771	68	69	6,099	49	50	1,099
1914.....	*Nil.*	.....	.....	*Nil.*	.....	.....	13	13	1,007	*Nil.*	....	.....

Year.	Iron and Steel. (*Continued.*)									Lead and Mfrs.
	Steel, Ingots, Blooms, Etc.			Sheets, Plates, Rods, Wire.			Tin and Terne Plates, Taggers Tin.			
	Long Tons.	Metric Tons.	Value.	Long Tons.	Metric Tons.	Value.	Long Tons.	Metric Tons.	Value.	
.....	86	87	$15,570	161	164	$8,019	26	26	$3,014	$2,441,166
.....	196	199	14,104	318	323	27,631	0.4	0.4	28	2,307,345
.....	292	297	25,974	14	14	1,220	42.2	42.9	1,813	2,416,082
.....	33	34	9,822	66	69	3,441	4.7	4.7	351	3,101,953
.....	60	61	10,389	42	43	2,630	14	14	6,273	3,139,908
.....	121	123	24,867	96	98	6,122	.....	.....	.....	2,511,850
.....	108	110	19,721	.....	.....	34,177	.....	.....	.....	4,067,574
.....	470	478	57,743	58	59	6,786	175	178	15,886	2,704,062
.....	418	425	60,191	*Nil.*	.....	.....	1	1	250	2,107,796
.....	*Nil.*	.....	.....	2	2	143	67	68	4,240	1,539,039

ear.	Salt.			Sulphur—Crude.			Tin in Blocks, Pig and Granulated.		
	Lb.	Metric Tons.	Value.	Long Tons.	Metric Tons.	Value.	Long Tons.	Metric Tons.	Value.
.....	2,089,234	948	$2,814	2,493	2,533	$58,887	519	527	$322,234
.....	611,912	278	893	1,713	1,741	36,858	557	567	375,763
.....	1,462,413	663	1,129	403	409	8,475	807	820	650,411
.....	1,166,049	529	1,686	301	306	5,759	562	571	492,415
.....	2,525,945	1,146	9,352	380	386	8,500	244	248	156,761
.....	1,617,705	734	1,700	16	16	284	441	448	294,649
.....	2,124,983	964	2,173	5	5	145	620	630	467,526
.....	449,025	204	646	*Nil.*	.....	.....	1,012	1,027	958,481
.....	73,551	33	105	1,015	1,032	20,314	589	598	591,729
.....	76,125,400	34,540	3,226	25	25	555	1,104	1,122	1,135,105
.....	5,196,300	2,357	14,349	309	314	7,074	802	815	647,017

(*a*) From Summary of Commerce and Finance of the United States. (*c*) Total exports of coin and bullion; is, includes both foreign and domestic. (*d*) Only approximately correct. The Bureau of Statistics ·ts only the value of silver ores exported, but a much larger amount of silver leaves the country in copper e, which is classified as copper ore, and no record is kept of its silver contents. The gold in copper matte rted is not included in the exports of gold given in the above table. These figures include ore of both stic and foreign origin. (*e*) Includes nickel oxide and nickel matte. (*f*) Includes chlorate, chloride, te, and all other salts of potassium. (*g*) Reported in barrels, but calculated to gallons, on a basis of 42 ns to the barrel. (*i*) Barrel of 400 lb. (*m*) Does not include coal used for fuel on vessels for foreign). (*n*) Included in other manufactures. (*o*) Antimony contents of regulus, etc.



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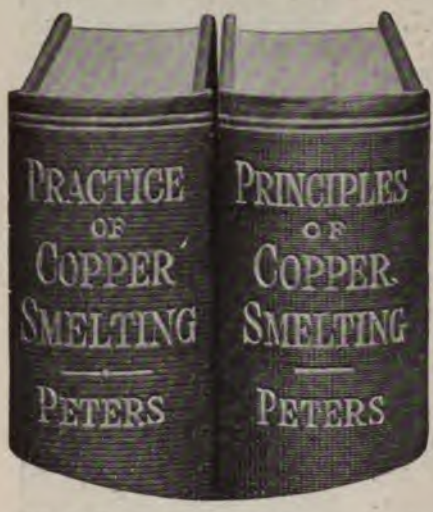

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